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ABSTRACT

The utilization of workshop accomodations in the countries of the Asian Region are examined and the study concludes that, in most schools, a single multipurpose workshop is more economical than the separate workshops for separate crafts that are in common use at present. Design criteria are developed for multipurpose "industrial arts" workshops that include woodwork, metalwork, electrical work, motor mechanics, textiles, ceramics, and so forth, indicating the effect of course content on space provision. The problem is approached of how design, while not duplicating but reflecting the atmosphere of a good modern industrial plant, would provide for the exploration of industrial knowledge and methods. Chapters suggest ways in which the general purpose or multifield laboratory can accept a variety of arrangements for teaching and learning in relation to some of the curricula current in the Asian Region. Included are the layout of equipment, design of seating, thermal comfort, noise and visual environment, work areas (individual and group demonstration), storage, and toilet and lavatory facilities. (Author/MLF)

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STUDY

5

THE DESIGN OF WORKSHOPS FOR ASIAN SECOND LEVEL SCHOOLS

ASIAN REGIONAL INSTITUTE FOR SCHOOL BUILDING RESEARCH

Sponsored by Unesco

COLOMBO

2

ASIAN REGIONAL INSTITUTE FOR SCHOOL BUILDING RESEARCH

STUDY - 5

THE DESIGN OF WORKSHOPS FOR ASIAN SECOND LEVEL SCHOOLS

by

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PREFACE

Education in the Industrial Arts is treated here as that area of general secondary education through which the child gains experience in practical activities. This experience is important as part of a wider range of educative experiences which, in their totality, prepare the child for life both as an individual and as a citizen. In addition, practical activity may sometimes direct the child, through the interest it arouses and the special aptitudes it reveals, towards further vocational studies.

Of the total enrolment in second level education in Asia, 92% of the pupils are in general secondary schools in most of which Industrial Arts is included as a curricular area. This study is concerned with the provision of accommodation for Industrial Arts teaching and learning in these schools. It is not concerned with the very different problem of providing facilities for purely Vocational Training.

In most countries of the Region much remains to be done in the field of Industrial Arts education, both by way of curriculum development, teacher training, construction of buildings and purchase of equipment. The per place costs, both capital and recurrent, of this section of education are inevitably very high indeed. Ironically the field of study is one which often finds little favour with parents or children who associate education with arts and science learning which, they hope, will lead to well understood, lucrative employment. Few parents in Asia appreciate the rate at which their countries are industrialising and that in other parts of the world, employment as a craftsman or technician is not only interesting and challenging but also socially acceptable. Moreover, it is frequently better rewarded than employment in many other fields. A craftsman in some countries will earn as much as a junior lecturer in a University.

The need therefore, in Asian secondary schools is to do everything possible by way of appropriate curricula, good teaching, and the provision of outstanding physical facilities to give Industrial Arts education the same aura of respectability as is already attached to education in the Arts and the Sciences. Good design of teaching spaces is a means of assisting in achieving this important aim.

What is perhaps most important in this paper is not so much the solutions that have been obtained, but rather the methods that have been used to evolve them. A well designed Industrial

Arts laboratory can only be produced after careful study of the activities which it is provided to house. The assistance throughout the design work of a specialist educationist is therefore essential in attempting to produce designs for Industrial Arts teaching space.

One of the main problems to which frequent reference is made in the paper is the differences in laboratory design as between urban and rural areas. Industrialisation relies for its success on sources of power. Over 70% of Asia's population is presently living in rural areas, most of which are not supplied with electricity. This situation is changing and, as the purpose of the paper is to provide guidance for those designing schools for the future, we have made frequent reference to the need - even in the smallest and simplest of rural Industrial Arts laboratories - to take into account this change when it occurs. The impact of the availability of power will be mainly on the space to be provided. It will involve future rearrangement of furniture in the laboratory and the introduction and correct location of whatever new power tools and machinery are appropriate.

There is an apparent contradiction between the title of the paper and the terminology used inside the cover. Educationists in the Asian Region are more likely to be familiar with the use of term "workshop"as a space in which to teach Industrial Arts activities and for this reason the paper has been entitled"The Design of Workshops for Second Level Asian Schools".In the text,however, we have preferred to use the term "laboratory", for the word more accurately describes the modern trend in teaching which is towards pupil experiment with material and methods. In this sense any space in which such activities take place can be more accurately called a "laboratory" or "a place set apart for experiment".

Finally,the authors would like to acknowledge the assistance of others in the preparation of this study. The original Consultant Educationist,the late Dr.C.E.Maningas, Programme Officer for Vocational Technical Education from Unesco's Regional Office for Education in Asia, worked on the paper for about 3 weeks before being taken ill. We have used and acknowledged in the text, the very considerable amount of material he so carefully prepared. Chapters 1 and 2 have benefited from the comments of collegues in the Institute, Mr. Senarath and Mr. Sheath and of Mr. Beynon of Unesco, Paris. The text has been edited and prepared for publication by the Institute's documentalist, Mrs. R. Kayser.

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SUMMARY

The object of Industrial Arts as an area of Secondary General Education is to help the child to develop basic practical skills through the use of common tools and to arouse interest in and simple understanding of industry and industrial processes. The experience gained by the child in this area of education may be either of very general use after leaving school or sometimes, through the interest aroused and the aptitudes revealed, may lead on to further, purely vocational studies.

As at present conceived in many countries of the Region, Industrial Arts, although part of general education, has a frankly vocational flavour: Syllabuses usually include common crafts such as wood or metal work and emphasis in teaching is on acquiring skills with tools and materials through the construction of personal projects. It is for this situation that workshops have now to be designed.

The more modern approach to learning however is through directed "discovery". In many ways this reflects the current changes in Science teaching and will demand similar changes in workshop design furniture and equipment as those already made in laboratory design if and when it is adopted in the Region.

Perhaps the most important conclusion to be drawn by the architect from a study of this situation is that spaces for Industrial Arts should be much less tightly tailored to the needs of specific subject fields than was the case in the past. Just as in design for industry, the trend is towards "general purpose" factories, so, in secondary general schools, the trends should be towards general purpose spaces for all Industrial Arts teaching and learning.

The study examines the utilization of workshop accommodation in the countries of the Region and it is concluded that if economic use is to be made of the facility, there is a case for a single multi-purpose workshop in most schools, rather than the separate workshops for separate crafts that are in common use at present.

Such an innovation may, of course, lead to initial resistance from educationists. In one Asian country in which only 5% of the second-level general schools had workshop facilities, it was said that "educators felt that, in view of different objectives and physical maturity of the pupils, separate workshops should be maintained." In many countries, policy makers have to decide on whether to give more children education in multi-purpose workshops or provide far fewer children with separate workshops for each craft. The designer can, in estimating the accommodation needs and calculating utilization factors for each element of accommodation, draw the attention of education authorities to requests for designs for workshops which are demonstrably to be under-utilized and explain some of the alternatives that might lead to more economic investment. Teacher training is, of course, also linked with the problem of better workshop utilization. There is a need in multi-purpose shops for teachers trained in all of the subject areas for which the shop provides facilities.

The study develops the design criteria for multi-purpose workshops indicating the effect of course content on space provision. Detailed design problems related to these criteria are discussed in the last three chapters.

R E S U M E

L'objectif de l'enseignement des travaux industriels (dispensés dans les écoles secondaires générales) est d'aider l'enfant à développer ses aptitudes de base (par l'emploi d'outils élémentaires), d'éveiller son intérêt pour, et aussi de l'aider à comprendre l'industrie et les processus industriels. L'expérience acquise par l'enfant dans ce domaine de l'enseignement peut être d'une utilité plutôt générale après sa sortie de l'école ou - grâce au fait que son intérêt ait été éveillé et ses aptitudes se soient révélées - peut l'encourager à continuer des études purement professionnelles.

Dans maints pays de la Région, l'enseignement des travaux industriels, bien qu'il fasse partie de l'enseignement général, est dispensé actuellement de façon plutôt professionnelle. Les programmes comprennent généralement des matières habituelles (par exemple le travail du bois ou du métal), et, dans l'enseignement, l'accent est mis sur l'acquisition de l'habileté avec les outils et les matériaux par la construction de projets personnels. C'est en fonction de cette situation que l'atelier moderne doit être conçu.

Les méthodes modernes d'enseignement favorisent cependant les "découvertes" dirigées. Elles reflètent les évolutions actuelles de l'enseignement des sciences en plusieurs manières. Si et quand les ateliers destinés aux travaux industriels seront introduits dans la Région, il faudrait y effectuer des modifications similaires à celles adoptées dans la conception de laboratoires, de mobilier et d'installations.

Cette étude fait l'analyse de l'utilisation des ateliers dans les divers pays de la Région. On en conclut que dans la plupart des écoles, la meilleure solution pour utiliser les ateliers au maximum, est de construire des ateliers polyvalents et non pas des ateliers distincts pour chaque branche, tels qu'ils sont actuellement en usage.

Il est évident qu'au commencement les éducateurs s'opposeront à une telle innovation. Dans un des pays d'Asie, où 5 % seulement des écoles secondaires générales possédaient des ateliers, les éducateurs étaient d'avis que, compte tenu de la diversité des buts et de la maturité physique de l'élève, il vaudrait mieux prévoir des ateliers distincts. Dans beaucoup de pays, il

appartient aux dirigeants de décider s'il est préférable de donner une éducation à un plus grand nombre d'enfants en prévoyant un atelier polyvalent, ou s'il vaut mieux prévoir des ateliers distincts pour chaque branche, mais pour un nombre d'élèves beaucoup plus réduit. L'architecte peut, en évaluant les besoins en espace d'accueil, et en calculant le facteur d'utilisation pour chacune des unités d'accueil, attirer l'attention des autorités responsables de l'éducation sur les demandes de construction d'ateliers qui pourraient se révéler nettement sous-utilisés à l'avenir, et leur proposer quelques autres solutions qui pourraient aboutir à un investissement plus économique. La formation de professeurs aussi,est naturellement liée au problème de l'utilisation plus rationnelle des ateliers. Les ateliers polyvalents nécessitent des professeurs formés dans les deux domaines pour lesquels l'atelier a été aménagé.

Cette étude développe les critères conceptuels pour les ateliers polyvalents. Elle présente l'effet que le contenu du programme exerce sur l'espace à prévoir. Les problèmes conceptuels s'y rapportant sont traités en détail dans les trois derniers chapitres.

CHAPTER - I

EDUCATIONAL ASPECTS

1.01 Educational Background

Secondary education in many countries of the Asian Region is currently subject to intensive and critical review and evaluation in respect of its purpose, organization and programmes. It is no longer conceived as the preparation of a selected few for higher education in the traditional disciplines. The tremendous increase in the number of students coupled with the wide range of ability they present, on the one hand, and the various man-power requirements for national development, on the other, have prompted reorganization or re-adjustment of the system of secondary education, as well as the introduction of new curricular content in many countries.

One of the most significant features in the field of curriculum development at the second level is the inclusion of various practical activities which were earlier thought to be appropriate only to vocational education.

The objectives of the introduction of these activities seem to range from integration of work and study as an aspect of general cultural education for citizenship, to identification of those students suitable for vocational or technical education at the diversification stage. Provision of opportunities to the large number of students leaving the secondary schools at various stages, to acquire the basic manual and manipulative skills likely to be helpful in gaining employment, is also considered important.

These objectives have been explicitly stated by many countries. For example, in Pakistan, practical or manual work is "intended to inculcate a sense of dignity of labour and to remove the widespread aversion which exists in our educated classes for work that dirties the hands" 1/. In Cambodia, 'practical activities' "are designed to develop manual dexterity and to awaken

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1/ Pakistan (Bureau of Education) Ministry of Education. Report of the curriculum Committee for secondary education (class 6-7) general introduction, schemes of studies, syllabuses - Rawalpindi (1960).

students' interests in areas where they have none" 2/. The new curriculum in Iran contains courses designed to discover student's interests and abilities and to stimulate them to enter technical and vocational schools 3/.

Table 1 indicates the periods allocated per week to practical activities in secondary general schools in a number of countries of the Region and shows a variety of approaches to locating this topic within the total learning experience of the student. In Ceylon, India, Japan, Korea, Malaysia, Pakistan, Philippines, Singapore and Viet-nam, practical activities are included as part of the studies in the lower secondary school but are excluded from the curriculum of the upper secondary school.

TABLE 1 - PERIODS PER WEEK, BY GRADE ALLOCATED TO MANUAL WORK IN SECONDARY GENERAL SCHOOLS

Country	GRADE						
	6	7	8	9	10	11	12
Burma	4	4	4	4	2	2	-
Cambodia	-	4	4	3	3	3	2
Ceylon	-	-	4	5	5	0	0
Republic of China	-	2	2	2	2	2	0
India	-	-	2	2	2	-	-
Indonesia	-	2	2	2	2	2	3
Iran	-	3	3	2	2	2	0
Japan	-	3	3	3	0	0	0
Republic of Korea	-	4-5	4-6	3-12	0	0	0
Laos	-	0	0	0	0	1	1
Mongolia	-	-	-	5	6	8	-
Pakistan	4	4	4	0	0	0	0
Philippines	-	10	10	0	0	-	-
Singapore	-	4	4	-	-	-	-
Thailand	-	-	5-7	5-7	5-7	12	12
Republic of Viet-nam	1	1	1	1	0	0	0
Malaysia	-	10	8	20	-	-	-

2/ UNESCO. *Regional Office for Education in Asia. General secondary school curriculum in the Asian Region. Bulletin. vol: no.2 March 1969, Unesco, Bangkok*

3/ UNESCO, *op.cit.*

In Laos and Mongolia the reverse is the case. Afghanistan does not include Industrial Arts activities in second-level academic schools while, in the remaining countries, listed in the table, they continue throughout secondary level education.

In Grades 11 and 12, Industrial Arts is only one of a large number of subjects and is almost invariably an elective.

The practical activities provided in the curricula of secondary general schools in the Region and given in Table 1, fall into three broad categories:-

i) Agriculture and farming
(gardening, agriculture, horticulture, dairy farming, poultry farming etc.)

ii) Art Crafts
(Carving, Painting etc.)

iii) Industry
(Woodwork, metalwork, electrical work, motor mechanics, textiles, ceramics etc.)

It is with the provision of physical facilities for education in the third category of practical activities that the present study deals. This group of activities is known as "Industrial Arts".

1.02 *The Basic Philosophy of Industrial Arts*

"Industrial Arts is a phase of general education that concerns itself with the materials, processes and products of manufacture, and with the contribution of those engaged in industry"4/ like the social sciences and other broad fields of subject matter, Industrial Arts is a curriculum area and not merely a subject or a course. Its content is cumulative in nature and ranges from simple to complex, and from performance in activities requiring tolerances to precision standards. The difficulty of the content in terms of what to teach, tends to increase with the level of instruction.

4/ MANINGAS, C.E. *A preliminary study of work education programmes in post primary schools, practical arts in general Secondary Schools,... Ministry of Education and Cultural Affairs, Ceylon. Colombo, 1967.*

Industrial Arts studies provide experiences that are useful for all students, whether or not they subsequently decide to work in the field of industry. For example the wise selection, care and use of the vast array of consumer goods produced by modern industrial technology, is as important to those engaged in vocational activities as to those working in industry itself.

The main purpose of Industrial Arts is thus to provide for exploration of industrial knowledge and methods and to develop interests and attitudes which will enable youth to adjust to the duties and responsibilities of a modern industrial- technological society. It is especially useful to those whose education at second level is terminal.

The general aims of Industrial Arts may be translated into specific objectives as follows:-

i) To acquaint the students with the various fields of industry, including the materials, products, problems and employment opportunities;
ii) To develop the appreciation of good design and craftmanship and the ability to select and use industrial products wisely;
iii) To develop desirable work habits, appreciation for the dignity of labour and ability to work co-operatively;
iv) To develop in the pupil a feeling of pride in his ability to do useful things and to develop leisure time interests;
v) To provide opportunities to satisfy creative desires and discover interests and aptitudes;
vi) To develop the ability to think rationally, plan work wisely, execute plans effectively, and appraise finished products intelligently;
vii) To develop an understanding of drawings and the ability to express ideas by means of drawings;
viii) To develop a measure of skill in the safe use of the problems involved in common types of construction and repair.

1.03 Industrial Arts in the Lower Second-Level School

The Lower Secondary School Industrial Arts programme is usually the most diversified of all and offers a variety of experi-

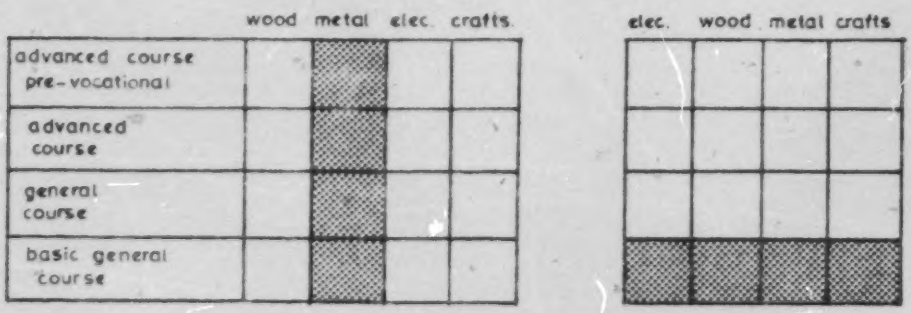
ences in organised laboratories (see Footnote).

Under the direction of specialized teachers, the students are provided with basic exploratory experiences in using many of the tools, materials, processes and products of the major industries. Through experiences in drafting, woodworking, metalworking, industrial crafts and the electricity electronics areas, the students can develop an appreciation of industrial design, good craftmanship, safe work habits, orderly procedures and an understanding of common tools, machines and devices.

Opportunities to study the underlying functions of industry and to explore their inter-relations are also part of the total programme. As a result, the student can assess and understand his interests, abilities, limitations and potentialities in modern industrial society. Through this type of general education programme, guidance can be provided in both prospective levels, educational and occupational.

1.04 Industrial Arts in the Upper, Second-Level School

The Industrial Arts programme at the Upper Second-Level usually enables a student to progress in one of two directions. (Figure 1)



vertical lateral

STRUCTURING OF INDUSTRIAL ARTS LEARNING AT THE UPPER SECOND LEVEL

figure.1.

Footnote: *The term "laboratory" is used throughout this paper as describing the spaces in which Industrial Arts teaching and learning takes place.*

The lateral curriculum approach enables the student to explore in a general way a variety of kinds of activity which are suited to his objectives, whilst the vertical approach, offers an opportunity to concentrate and specialise in a selected of industrial work.

At the Upper Second-Level, a good industrial arts programme, therefore, provides a broad general background for some students, while for others, it provides pre-vocational experiences. Whichever path the student selects, numerous opportunities for experimentation, problem-solving, the application of scientific principles and the integration of physical, chemical and electrical aspects of the materials and processes of industry are made possible.

1.05 *Fields of Industrial Arts Activity in the Curricula of the Countries of the Region.*

The main fields of Industrial Arts activity in the Region are shown in Table II, below. It will be seen that almost all

TABLE II - INDUSTRIAL ARTS FIELDS IN SECONDARY GENERAL CURRICULA IN THE ASIAN REGION

Country	FIELD OF ACTIVITY				
	Wood	Metal	Electricity	Technical Drawing	Others*
Afghanistan					X
Burma	X	X		X	X
Cambodia	X	X	X		X
Ceylon	X	X		X	X
Republic of China	X	X	X	X	X
India	X	X	X	X	X
Indonesia					X
Iran	X	X			X
Japan	X	X	X	X	X
Republic of Korea	X	X		X	
Laos	X	X			X
Malaysia	X	X	X	X	X
Mongolia				X	X
Nepal	X	X	X		
Pakistan	X	X	X	X	X
Philippines	X	X	X		X
Singapore	X	X	X	X	X
Thailand	X	X			X
Republic of Vietnam					X

*Others include ceramics, textiles, cane and bamboo work, mechanics leather work or fields not specifically mentioned.

countries include wood and metal work in their curriculum and about 50%, electricity and technical drawing.

The course material for similar fields varies considerably from country to country. In the Republic of China, for example, the syllabus is framed in very general terms and its development in detail left to the teacher. In Ceylon, India, Pakistan and Thailand, comparatively more detail is given. For the architect designing the individual Industrial Arts facility, a detailed syllabus or a fully developed scheme of work is most useful. There is, however, a danger in designing for detailed requirements, for syllabuses and teaching schemes are subject to regular review and not infrequent change. From this view point, designing to accommodate the varied situations that may develop from a general syllabus, may result in the creation of a more satisfactory, long-term, design solution.

It is, moreover, and in this connection, reasonable to assume that the wave of curriculum reform that has fundamentally changed science and mathematics teaching and learning in the Region, will, in time be reflected in similar changes in the Industrial Arts area. Just as in science, the main feature of change has been from the assimilation of facts (many of which become outdated almost as soon as they are learned) to learning to learn, so in Industrial Arts the change may be from learning specific skills to studying the approach to an industrial problem. In countries outside the Region where curriculum reform of Industrial Arts is actively in progress, Industrial Plastics, Industrial Ceramics, Industrial Crafts, and Power Mechanics outnumber the traditional fields such as Woods and Metals.

Whilst the architect has, of course, to design for the existing curriculum situation, it is very important that he creates spaces that are readily adaptable to possible future requirements.

1.06 *Present Instructional Methods in Industrial Arts*

An instructional method refers to a teaching procedure designed to reach pre-determined learning goals. Industrial education teachers make extensive use of several types of teaching methods such as demonstrations, questioning, class discussions, lectures and self-instructional devices.

The process of lesson planning includes 'how' material is to be taught as well as 'what' is to be taught. Factors influencing methods include safety, facilities, age of pupils, time of school

year and pupil abilities. There is no single best method of teaching, but there are learning objectives for which certain methods are appropriate. Some of the commonly used methods are:-

METHOD	*PURPOSE OF METHOD*
Lecture/Discussion	To present to a complete teaching group - usually seated - informational material or an explanation or a process. Frequent use of charts, chalkboards, films or other visual material, includes a question and answer, discussion or review and should stimulate thinking.
Demonstration	To show manipulative operations and equipment and to clarify principles and theory - usually to a section of the main teaching group standing round the site of the demonstration.
Illustration	Where time or cost make demonstration difficult the operation may be illustrated by chart, drawing, film, to the complete teaching group - usually seated.
Practice	By pupils, working either individually or in groups to develop performance skill in the laboratory - usually standing if exercising the manipulative or other skills demonstrated by the teacher earlier.
Conference	Of either the complete teaching group or by a section of it - usually sitting informally - to get opinions and ideas, to encourage group thinking, and to get acceptance of courses of action discussed and modified by the group.

A common way of organising material for Industrial Arts teaching is to break the subject matter to be taught into small units, which form a correct sequence for instructional use. These units may be listed separately as "manipulative operations" (i.e. the things students *do*) and "information topics", (i.e. what the students *know*). Manipulative operations or "doing" units still form the basis for preparation of a list of "demonstrations" to be

given by the teacher while the information topics or "knowing" units, would be the "topics for full group discussion".

On the basis of these lists, the teacher should prepare a workable teaching plan which would include the list of suggested projects, teaching aids and activities.

While an exercise in filing, making joints, etc. may have some value in certain areas like welding, the manipulative operations and skills and processes can be learnt by making useful 'projects' catering to the interests and abilities of the pupils. Although the making of an article or project is not the prime purpose in Industrial Arts, it is an excellent vehicle for learning. The assumption is that during the construction of the project, related technical and other topics of information and investigation will be injected or "sandwiched in" as construction progresses.

The student should either propose his own project or accept one assigned by the instructor as worthwhile; he should see the project through from start to finish, doing the various operations himself; when the job is complete, he should evaluate his own work, with a view to taking stock of what he has learned and determining where improvements may be made in his procedure or workmanship.

From the standpoint of class organisation and teaching procedure, projects may fall into several different classifications. In an 'individual project' all operations and processes are performed by a single person. A 'group project' is undertaken by several students or a whole class. The term "project" here may also cover services performed, as for instance, planning and designing a total panel. "Mass production projects" differ from the group project in that they offer opportunities for stimulating methods of production and will give participants a limited view of mass production techniques.

There are various methods of assigning projects to each grade of students. One approach is for the teacher to assign the same project to all students. This is often adopted in the initial stages of a course. The second approach is to offer a variety of projects, ranging in scope and difficulty, from which each student will select one exercise which conforms with his ability.

Of course, although a variety of projects is offered, the fundamental process which the teacher wishes all students to experience, will be incorporated in each project.

Finally, and usually towards the end of the programme, students will be given freedom of choice in the planning and designing of their own projects. At this stage the role of the teacher becomes virtually that of co-worker.

As was briefly mentioned above, a characteristic of Industrial Arts in most Asian countries is continued adherence to a traditional curriculum structure and content. The subject has, with the exception of the occasional introduction of electronics and automobile mechanics, changed but little over the years with woodwork and metalwork remaining the dominant fields in the area. As far as content is concerned, emphasis continues to be placed on tools, materials and personal project construction. In woodwork and metalwork for example, students continue to make bowls and trays although for years past these items have been provided by industry in a wide variety of plastics. This sort of change is not reflected in Industrial Arts teaching.

It is, however, reasonable to assume that a wave of curriculum reform and development will, in time, sweep over the Industrial Arts area. Just as in science, the main feature of change has been from the assimilation of facts to learning about concepts, so, in Industrial Arts, the change may be from a field of study such as wood or metalwork to "communications, construction, manufacturing and power"5/.

In designing for the present, the architect, bearing these probable curriculum reforms and developments in mind, will need to create spaces that are readily adaptable to future requirements.

5/ FLORIDA. (State). *Department of Education. Industrial Arts; a study of Industrial Technology. Consultants; Ralph V. Steeb (and) John J. Geil. Tallahassee, Florida, 1968.*

CHAPTER - 2

ACCOMMODATION REQUIREMENTS

2.01 General

The Industrial Arts facility is probably the most expensive element in a general secondary school. It requires special furniture, water services and often gas and three-phase power. The equipment, whether it be a set of carpenter's hand tools, a potter's wheel or metal lathe, is always costly. Above all, teachers trained in this field are often in very short supply and, unless wisely used, will prove an expensive and recurrently wastfull asset.

It follows from a consideration of these factors that all Industrial Arts facilities must be very carefully tailored to the precise teaching needs in respect both of utilization during the week and of size in relation to occupancy. In other words there must be neither too many industrial science laboratories nor must they be too large. The old traditions of providing, for example, a separate wood working shop and a separate metal working shop, irrespective of the size of the school and the number of periods taught in these subjects, must be critically reviewed and, where such an arrangement is found wasteful, alternative solutions sought.

2.02 Laboratory Accommodation Potential

The potential or possible number of periods that an Industrial Arts laboratory can accommodate per week will vary from place to place. Forty periods is however a common potential in many countries of the Asian Region. No laboratory can of course be used for 100% of its potential. Time is needed between periods for preparation and some flexibility in use must also be accorded to the person constructing the timetable for all of the other activities in the school.

Experience shows that in a small, one or two stream general secondary school, the practical potential for an Industrial Arts laboratory is about 90% (36 periods) and in a larger schools 80% (32 periods).

A typical allocation of time for practical arts in the secondary school curricula in the Asian Region is as follows:-

Grade 8	4 periods
Grade 9	5 periods
Grade 10	5 periods
TOTAL	14 periods

The students may be required to study two subjects, for example, metalwork and woodwork. The resulting timetable for the laboratories or workshops should be

Grade	*Metalwork*	*Woodwork*	*Theory*	*Total*
8	2	2	-	4
9	2	2	1	5
10	2	2	1	5
TOTAL	6	6	2	14

If there are 40 periods in the week and only one class, stream or section in each grade, then the use of the metal workshop will be

$$\frac{6}{40} \times 100 = 15\%$$

The woodwork shop will also be in use for 15% of the week and both shops unused for 85% of their capacity. Moreover, the specialist teacher will have to be assigned other duties for he too will have only a 15% utilization factor or 30% if he is trained and able to teach both metal *and* woodwork.

Solutions have been sought to this problem and some are listed below:-

a) In Cambodia, some Industrial Arts teachers have been trained to take two areas such as metal and woodwork.

b) In Singapore, and in an urban situation, Industrial Arts is taught in centrally located laboratories or workshop from nearbye schools. This permits optimum utilization of both teachers and accommodation.

c) In a few other countries, workshops are only provided in schools having several classes, sections or streams in each grade, thus ensuring optimum utilization in respect of capital and recurrent expenditure.

For the example given above and if it was required to obtain high utilization of the accommodation and equipment, the number of streams in each grade would have to be as shown below:-

Grade	*Metalwork*	*Woodwork*	*Theory*	*Totals*
8(a)	2	2	-	4
(b)	2	2	-	4
(c)	2	2	-	4
9(a)	2	2	1	5
(b)	2	2	1	5
(c)	2	2	1	5
10(a)	2	2	1	5
(b)	2	2	1	5
TOTALS	16	16	5	37

The utilization in both metalwork and woodwork would then be given by

$$\frac{37}{40} \times 100 = 92\%$$

If there happened to be 3 classes or streams in grade 10 or if it was desired to lower the utilization to 90%, then the theory periods could be taken in ordinary classroom accommodation.

A study of the periods allocated to practical education in the various countries of the Region suggests that in all cases except for Indonesia, Iran and the Philippines, where there are sufficient periods of Industrial Arts in the time table of single stream schools fully to utilize a multi-purpose shop, two- and in some case three-stream schools are needed if economy of use of teacher and multi-purpose laboratory is to be achieved. (*see* Table III).

The most important conclusion to be drawn from Table III is that a single, multi-purpose laboratory is all that can be economically justified, both in respect of capital *and* recurrent investment in most second-level schools of the Asian Region and that it is only in the very large, upper second-level urban schools that separate laboratories may occasionally be justified for separate subject fields.

This study is thus confined to the examination of the main problem which is the design of multi-purpose workshops or laboratories. The general adoption of this type of Industrial Arts teaching may, however, present difficulties.

TABLE III - MINIMUM SIZE OF SECONDARY SCHOOL TO MAKE ECONOMICAL USE OF ONE, MULTI-PURPOSE WORKSHOP

COUNTRY	SIZE OF SECONDARY GENERAL SCHOOL IN STREAMS OR SECTIONS PER GRADE (see note)
Cambodia	Two form entry*
Ceylon	Two form entry
Republic of China	Two form entry
India	Three form entry
Indonesia	One form entry
Iran	One form entry
Japan	Three form entry
Republic of Korea	Three form entry
Laos	Three form entry
Mongolia	Three form entry
Pakistan	Two form entry
Philippines	One form entry
Singapore	Three form entry
Thailand	Three form entry
Republic of Viet-nam	Three form entry

Note: *This table has been calculated from the latest curricula available in the Institute*

**Two form entry* *means that there are two streams, classes or sections in each grade.*

2.03 *Educational Resistance to Change*

The idea of combining in one laboratory such diverse subjects as wood and metal working and possibly ceramics and electricity, is one which is likely to meet with stiff resistance from the inspectorate and teachers who have been trained and who have practised in unit laboratories. In a report on Industrial Arts teaching from one country of the Region it was said that, "Educators feel that, in view of different objectives and physical maturity of pupils, separate shops should be maintained..." This, it should be noted, was in a situation where the scarcity of funds for Industrial Arts laboratory construction was such that, "of 6047 schools offering (Industrial Arts), only 300 have workshops for general wood working, hundred for general metal, 301 for textile weaving and hundred for pottery".

Obviously at policy making level. a decision has, in such a dramatic yet common situation, to be made on whether to give more children Industrial Arts education in multi-field laboratories or far fewer children in grossly under-utilized, single field industrial Arts laboratories.

Coombs 6/ puts the alternative succinctly,"There is a strong case to be made for most if not all the specific tasks that fit into an enlarged frame of educational aims. But is it possible to achieve them all? It is possible to achieve a multiplicity of educational aims, while spreading opportunities to a larger portion of the total population - and to do this without suffering an erosion of quality that will impair all the aims? Is there not a grave risk that in seeking to adjust its old aims and priorities to accommodate new ones, and in its anxiety to please every one, an educational system may find itself with a confusion of aims, with no priorities at all, and forced to resort to "papier maché" to conceal its bare spots?"

The changes to be faced in the design of laboratories for Industrial Arts are two fold. First, the need to build multi-field laboratories in order to make better use of the money spent on buildings and teachers' salaries and, secondly, to design these laboratories in such a way that they meet, not only present curricula needs but also the changed curricula of the future. "Once (a building) is built to fit education's changing technology, it stands firmly for at least two or three generations to thwart any serious changes in the traditional deployment of space, time and students". 7/

6/ COOMBS, P.H. *The world educational crisis a systems analysis.* O.U.P. London 1968 p.103

7/ BEYNON, J. *Educational architecture v. educational change in Educational costs and productivity.* (Paris: Unesco/IIEP, Dec. 1967) (Mineograed)

CHAPTER - 3

COURSE CONTENT AND PHYSICAL FACILITIES

3.01 *The Elements of the Laboratory*

It was concluded in Chapter 1 that the main fields of activity at present offered by Unesco's Asian Member States in the Industrial Arts area of secondary general education are woodworking, metal working and electricity. In Chapter 2 it was shown that for economic use of space, equipment and possibly also of teachers, a single multi-field laboratory will satisfy the needs for Industrial Arts teaching and learning in most countries of the Region.

In designing for these circumstances and bearing in mind the possible curricula changes that will inevitably occur in coming years, the architect will require to understand the common features of Industrial Arts teaching in every field rather than the different detailed requirements for say wood as opposed to metal working.

A study of the various curricula of the Region shows the following common accommodation requirements:-

i) Storage space for raw material
ii) Storage space for finished work
iii) Storage space for tools and small, movable equipment
iv) A work room for the teacher
v) An area in which a group of students can watch a demonstration given by the teacher
vi) Space for fixed machinery
vii) Work spaces for individuals (not at machinery)
viii) Common work places to which all students may come
ix) A space for students to plan projects (making drawings, estimates etc.)
x) A place for changing to working overalls and for washing at the end of the period.
xi) Storage space for students' books and belongings.

3.02 *The Syllabus and the Physical Needs*

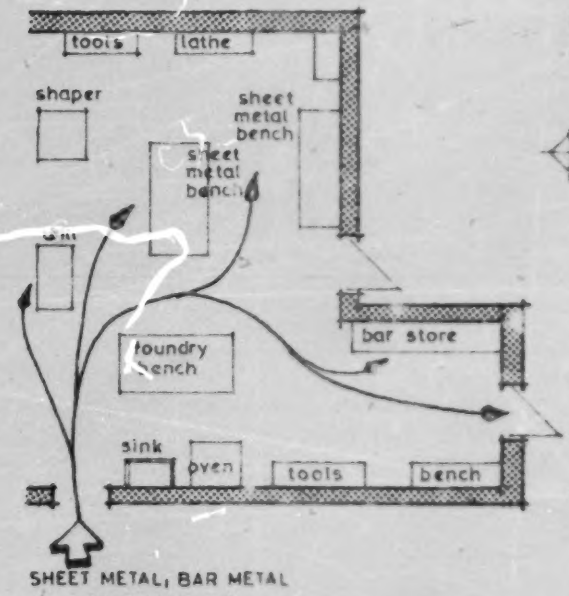
The way in which a syllabus can be studied to derive accommodation elements is indicated below for a woodworking situation:

I -	Orientation	
	Safe practices in the laboratory; characteristics of common timbers and terminology;	- in demonstration area
	job analysis and planning; making estimates of materials needed and calculating costs.	- in planning area
II -	Setting out	
	Getting out material	- from raw material store
	Setting out with rules, gauges, squares, testing angles	- demonstration area and at individual work space.
III -	Cutting stock with saws	
	Band saws	
	Theory underlying design and action of cutting tools; saw to a line with hand saws; saw with mitre box saw; machine saw.	- in demonstration area; at individual work space. at fixed machine
IV -	Cutting to basic form with hand tools	
	Hand planes	- in demonstration area and at individual work spaces.
	Squaring a board to dimensions; chisels, scraper, spoke-shave;	
	sharpening of handle tools.	- at fixed grind stones at common work bench.
V -	Common wood joints	
	Lap, dado, mortise and tenon joints	- at individual work spaces.
VI -	Sanding	
	Abrasives and methods	- at demonstration area and individual work space.
VII -	Fastening	
	Glueing	- at common glue bench
	nailing, screwing	- at individual work-space.
VIII -	Finishing	
	Preparation, stains, wood fillers, shellac.	- at common finishing area.

IX - Projects - suggested

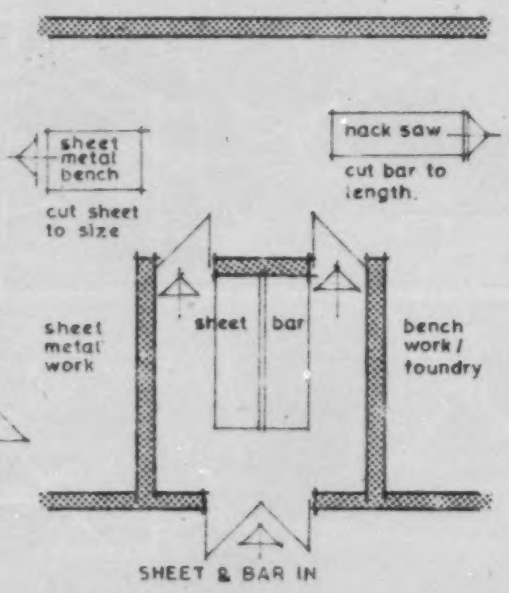
Bookholder, book end - finished work store.
Letter holder

Unstated but implicit in the foregoing is the need for tool storage, for a teacher's room and for washing and changing facilities. As one of the expected outcomes of Industrial Arts learning is an understanding of industrial processes, it is important that the laboratory through the inherent quality of its design, both descriptively and prescriptively, assists in the achievement of this aim. There should be a carefully arranged flow sequence into and out of the raw material store, to the work bench/machine, to the finished work store and out. A teacher will find it much more difficult to explain and illustrate industrial processes in an ill-considered laboratory such as that shown in Figure 2 than in a carefully designed space such as in Figure 3.



CONFUSED MOVEMENT OF MATERIALS

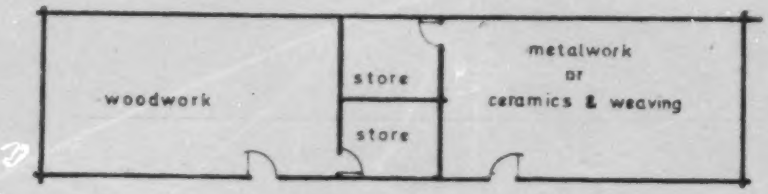
figure. 2



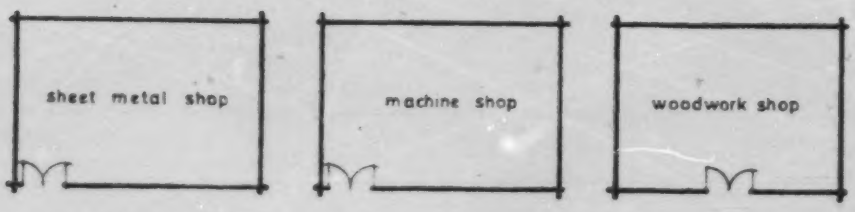
LOGICAL FLOW OF MATERIALS FROM VEHICLE TO STORE TO LABORATORY

figure. 3

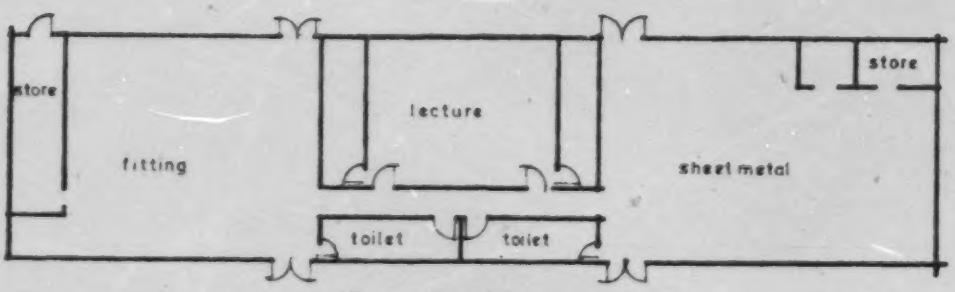
The common accommodation requirements for Industrial Arts laboratories, outlined above, coupled with the need to accommodate possible future changes in curriculum, suggest the need in the Asian Region for spaces designed for several general, rather than for one specific purpose. The Philippines, Cambodia and Hongkong have examples of schools in which multi-field laboratories or workshops already exist. Indeed study of the many drawings of workshops for second-level schools in the Institute's collection of drawings of Asian, Second-Level Schools, indicates a uniformity of plan shape and of other design features, the main difference between which are the internal dispositions of furniture and machinery. Figure 4 illustrates this point.



Ceylon



Singapore



Cambodia

SIMILAR GENERAL DESIGNS FOR INDUSTRIAL ARTS FACILITIES figure. 4

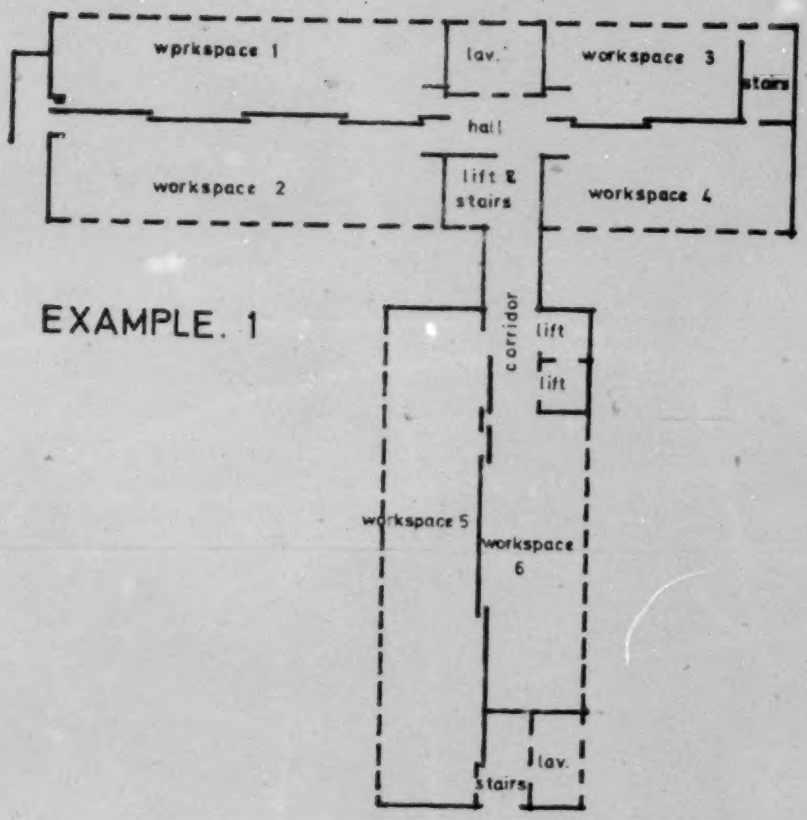
The outstanding question and one that is dealt with in the pages that follow, is, if multi-field laboratories are to be increasingly adopted in the Region as an economic means of solving the problem of accommodation for Industrial Arts education, what form should they take?

3.03 *The Laboratory and the Factory - Design Similarities*

It is, perhaps, no coincidence that the need for general purpose (G. P.) Industrial Arts laboratories for education reflects the current trend towards G.P. spaces for industrial production. Factories in many parts of the world are now commonly designed for sale or lease with neither a particular company nor a particular process in view at the design stage. The facilities offered by developers of this type of building usually comprise a carefully designed building envelope which provides a suitable environment (adequate illumination, thermal comfort etc.), storage, toilet and office facilities together with a work space adequately supplied with service inlets and outlets (electricity, gas, water, drainage etc.). The work space itself and its attendant stores are such as to permit a wide variety of arrangements of machines and processes.

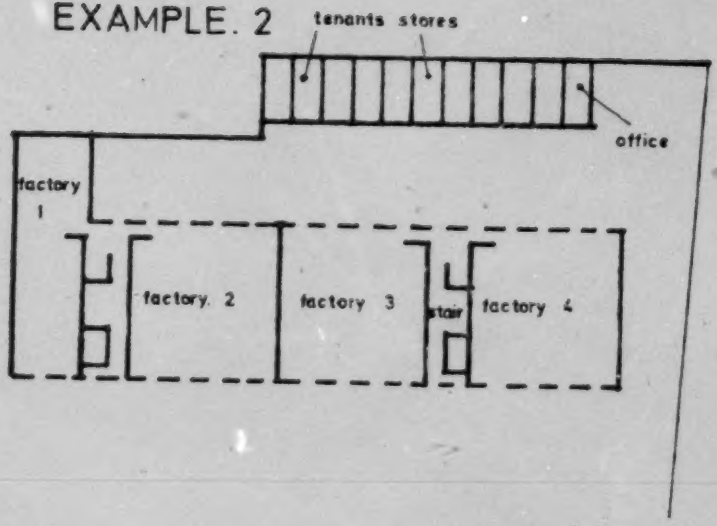
Figure 5 illustrates typical examples of such general purpose factories.

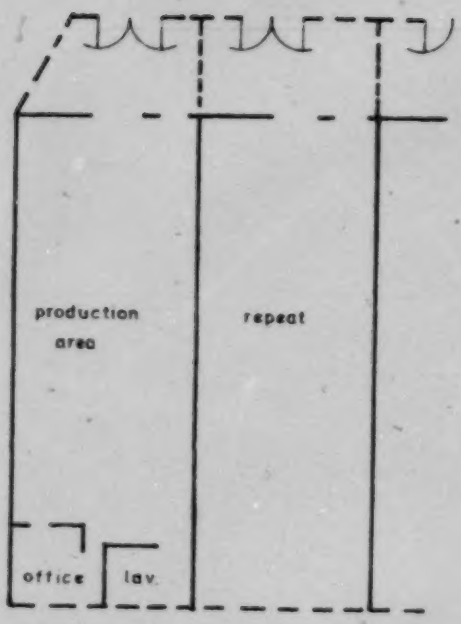
The approach adopted in this study follows this trend; reasonable, it is argued, for if one of the aims of education undertaken in the Industrial Arts laboratory is to provide for an exploration of industrial knowledge and methods, then it is appropriate that the exploration takes place in surroundings which, whilst not duplicating, at least reflect the atmosphere of a good modern industrial plant. The next chapter approaches the problem of how through design, this atmosphere might best be achieved and succeeding chapters suggest ways in which the general purpose or multi-field laboratory can accept a variety of arrangements for teaching and learning in relation to some of the curricula, current in the Asian Region.



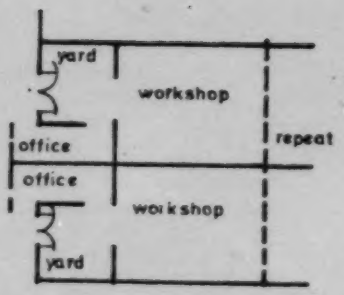
EXAMPLE. 1

EXAMPLE. 2





EXAMPLE. 3



EXAMPLE. 4

GENERAL PURPOSE FACTORIES FOR INDUSTRY figure. 5

CHAPTER - 4

DESIGN OF MULTI-FIELD LABORATORIES
- General Concepts

4.01 General

The multi-field Industrial Arts laboratory includes three basic elements of accommodation (3.01 above). These are spaces for:-

i) Work (individual, group demonstration)
ii) Storage
iii) Toilet

In addition, the total space provided must have an adequate environment in respect of illumination, thermal comfort and scale of furniture and fittings. There should be provision for services in a way that is adaptable for a variety of possible user requirements and, finally, the structural and constructional features of the building must be such as to permit the admission and location of any of the various sorts of machinery, and suitable for the different types of wear associated with teaching and learning, both now and in the future.

4.02 Spaces for Individual and Group Work

The required capacity of laboratories will vary from country to country ranging probably from as few as sixteen up to as many as 40 places. For general planning purposes what is thus needed is a *per place area* which can be used as a basis for the design of laboratories of any capacity.

The calculation of the per place area must obviously be based on the common combinations of fields of study for which laboratories are likely to be required.

These are indicated in Table IV below:

TABLE IV - INDUSTRIAL ARTS AREAS IN THE CURRICULA OF ASIAN COUNTRIES

COUNTRY	Combinations of subjects for which multi-field laboratory required
Afghanistan	Handicrafts
Burma	Woodwork
Cambodia	Electricity; sheet metal work; fitting; woodwork
Ceylon	Woodwork; weaving; ceramics; metalwork
Republic of China	Woodwork; metalwork; rattan and bamboo work; masonry; electricity
India	Woodwork; metalwork; leather work; spinning and weaving; clay modelling and papier maché work
Indonesia	Various, including woodwork and metalwork
Iran	Woodwork; metalwork
Japan	Woodwork; metalwork; electricity; and various others
Republic of Korea	Woodwork; metalwork
Laos	Woodwork; metalwork
Malaysia	Metalwork; woodwork; electricity, power mechanics
Mongolia	Production
Nepal	Spinning; weaving; woodwork; metalwork; electricity; motor mechanics; polishing and finishing (of wood and metal)
Pakistan	Woodwork; metalwork; electricity and electronics;leathercraft; graphic arts; pottery and ceramics; building construction.
Philippines	Woodwork; metalwork; electricity
Singapore	Woodwork; metalwork; basic electricity
Thailand	Metalwork; woodwork
Republic of Vietnam	Carpentry; forging and welding; fitting and electricity

The per place work space calculation for any field of activity will have to take into account:-

i) Individual work space area plus circulation about the area;
ii) The areas for common activities (such as the glueing table in woodwork or the forge in metal work) plus the associated circulation areas;
iii) An area near one of the individual or other work spaces for demonstration to small groups;
iv) An area for work space storage (in addition to the main storage facilities which are separate and discussed below).

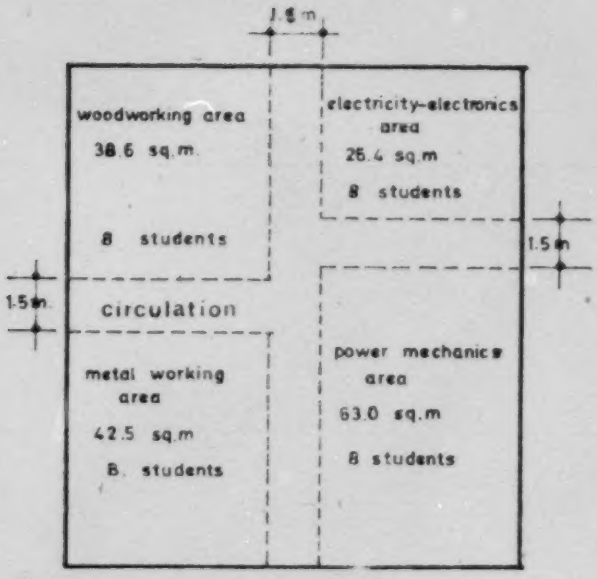
Annex I suggests a method by which these basic, per place areas can be calculated. The basis of the calculation is a student group of 8, multiples of which will give multi-field industrial arts classes of 16, 24, 32 and 40 - all common class sizes in the various countries of the Region.

The per place areas which include strictly for activities in the present syllabuses in the countries of the Region are calculated in Annex I and tabulated below in Table V.

TABLE V -NETT PER PLACE AREAS (SQ.M.) FOR VARIOUS ACTIVITIES IN MULTI-FIELD INDUSTRIAL ARTS LABORATORIES

Field of Activity	Area per place sq. metres
Woodworking	4.70
Metal working (fitting and sheet metal)	5.30
Electricity/Electronics	3.30
Spinning and Weaving	7.20
Ceramics (pottery and clay craft)	5.00
Rattan and Bamboo work	3.90
Leatherwork	2.75
Masonry	3.05
Power mechanics (Motor Mechanics)	7.87

Clearly where several activities are combined in one laboratory, a space for circulation and movement of materials will be needed between each activity area as is shown in Figure 6. An allocation of part of this circulation to the nett areas in Table VI will give the gross area required (Table VI, Column [iii]).



32 PLACE LABORATORY - SIZE TO ACCOMMODATE FOUR ACTIVITY FIELDS

figure. 6

The application of these areas to the design of laboratories for the various combinations of Industrial Arts fields in the countries of the Region will be considered further below, after discussion of the other elements of space required in a laboratory namely those for storage and for toilets.

TABLE VI - NETT AND GROSS AREAS REQUIRED FOR INDUSTRIAL ARTS ACTIVITIES IN VARIOUS FIELDS FOR GROUPS OF EIGHT STUDENTS

Field of Activity (i)	*Nett Area required for 8 students* sq. m. (ii)	*Gross Areas required for 8 students* sq. m. (iii)	*Gross per place areas* sq. m. (iv)
Woodworking	38.6	49.0	6.1
Metal working (fitting and sheet metal)	42.5	53.0	6.5
Electricity/Electronics	26.4	34.0	4.25
Spinning and Weaving	57.5	70.0	8.75
Ceramics (pottery and clay craft)	40.0	50.0	6.25
Rattan and Bamboo work	31.2	40.0	5.0
Leather work	22.0	32.0	4.0
Masonry	24.4	34.0	4.25
Power mechanics (Motor mechanics)	63.0	76.0	9.5

4.03 Storage in the Laboratory

Any storage space should be arranged to provide for:-

a) Receipt of new items (from outside);
b) Storage in a way that:-
   i) provides for selective withdrawal;
   ii) provides a suitable environment in relation to the items stored;
   iii) permits rapid stock checks;
c) Issue to preparation or working areas as and when required;
d) Security in relation to the value of the items stored.

Raw materials for Industrial Arts activities may be distinguished as either bulky or small. For woodwork, timber may be delivered in 3 or 4 metre length and plywood in full size sheets. The same is the case with bar and sheet material for metal work. Rattan and bamboo will be in long lengths and clay for ceramic work will usually be delivered in bulk.

As far as wood and metal are concerned, some schools are supplied with pre-cut materials in short lengths, thus simplifying the storage problem and also saving the students' time in the laboratory. Practices in this respect vary from country to country and even, within a country, from one district to another.

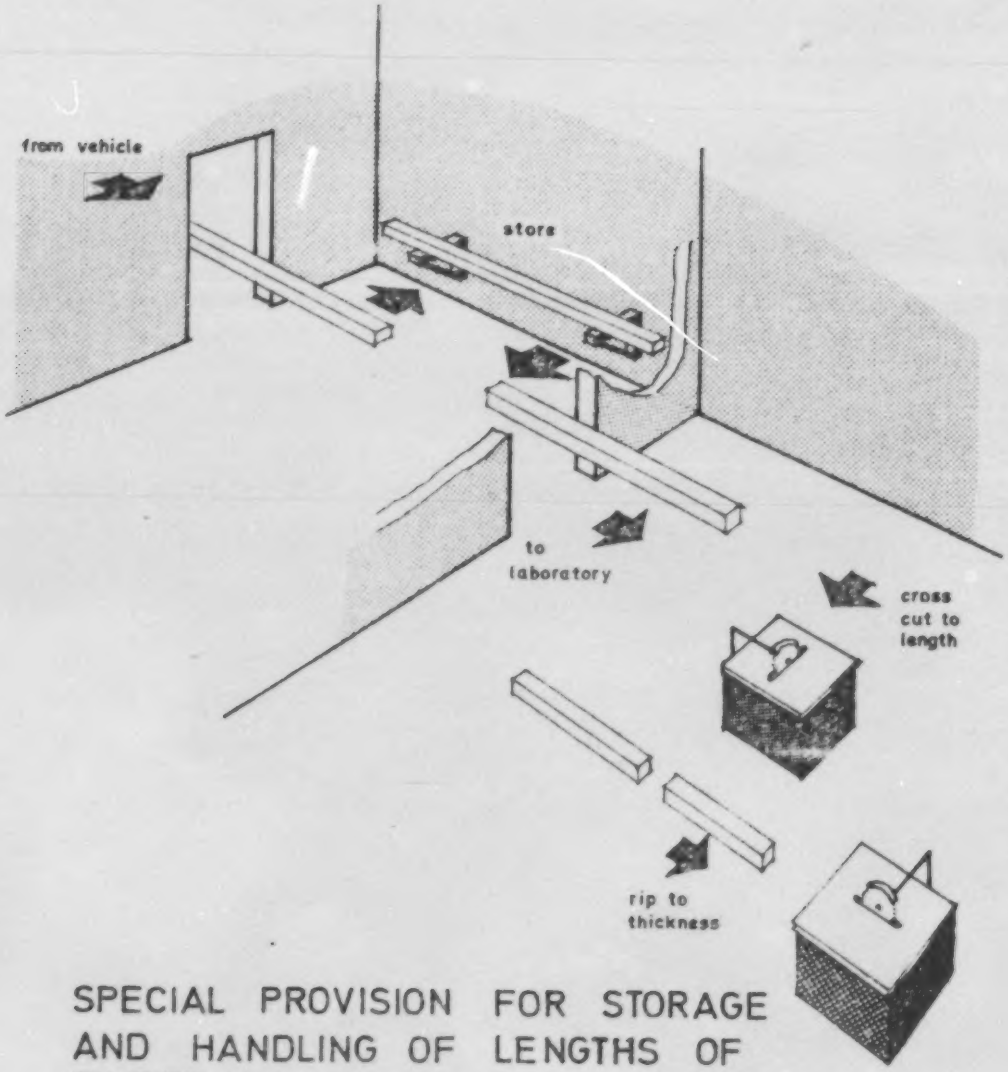
Activity fields such as electricity/electronics, weaving, leatherwork and the like require storage almost exclusively for small items.

The size of the stored items is important as it effects not only the quantum of space required, but also the access into and out of it. Figure 7 indicates the special provision required for timber storage for woodworking. Similar storage problems are associated with all other fields of activity.

Design of storage space for a multi-field laboratory presents somewhat greater problems than the design of the laboratory itself. For Ceylon, for example, (Table IV), a multi-field laboratory could be designed - as is shown in Chapter 5 - to house woodwork, metalwork, ceramics and weaving.

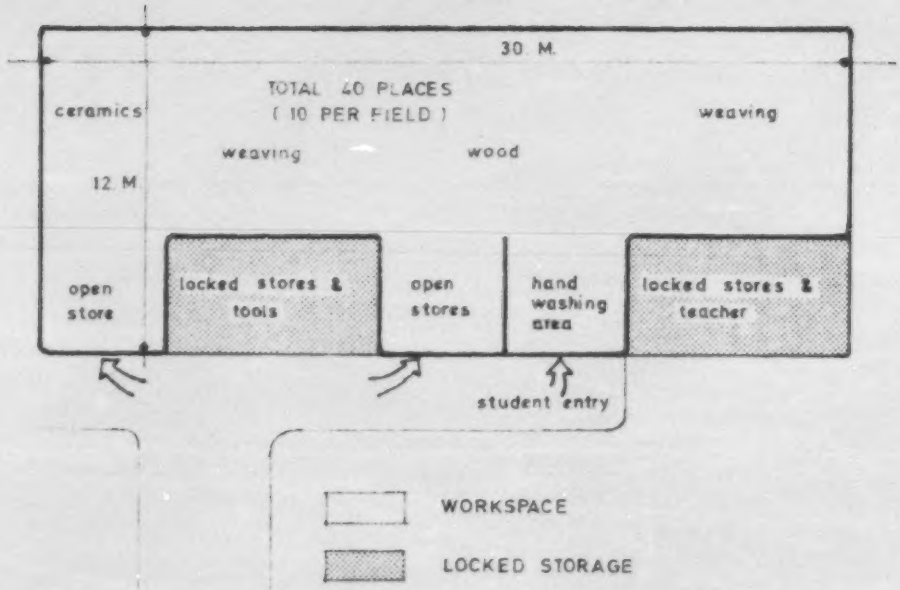
A judgement on the value of the materials (and tools) to be stored and an informed opinion on the risk of petty pilfering will be necessary first to establish whether lockable stores or spaces open to the laboratory are to be preferred. Clearly there is little risk of pilfering a 3m x 10cm x 5cm balk of timber, nor of the theft of clay or of big sheet of plywood or steel. These items can be considered for storage in convenient additional areas in the main laboratory space. Small items of raw materiel, infrequently used tools and finished work, on the other hand, require security of storage and lockable space(s) should be provided for them. In practice it may be considered difficult to decide when a piece of wood is small enough to be put in a security store and for this reason in many schools, all materials are stored in one large, lockable space. A solution in respect of the Industrial Arts activities for Ceylon is shown in Figure 8 as a possible response to a similar situation.

At the outline planning stage (indicated in Figure 8) an estimate has to be made of the approximate storage area to be provided. This presupposes a knowledge of the scale on which tools and other equipment, as well as raw materials are supplied to schools. Study of existing conditions should not be relied on too



SPECIAL PROVISION FOR STORAGE AND HANDLING OF LENGTHS OF TIMBER

figure. 7



MULTIFIELD LABORATORY SUITABLE FOR CEYLON INDUSTRIAL ARTS CURRICULUM

figure. 8

heavily in estimating needs for, in many countries of the Region, Industrial Arts is still the "poor relation" and supplies of materials and tools sometimes fail to match the requirements of the schemes of work. As the subject gains in importance and is assigned a higher proportion of the education budget, more supplies will be provided. Storage facilities should therefore be designed with this improved situation in mind. Equipment lists in individual countries may give information on the spaces required but perhaps the best general reference at the present time is the Unicef Guide List EVE 8/ which suggests basic items of equipment for -

Carpentry and Woodwork - Elementary and more advanced
Sheet Metal Work - Elementary and more advanced
Auto mechanics - Elementary and more advanced.

8/ UNICEF. Unicef guide list EVE. Unicef. New York 22 Sept. 1964.

A study of the EVE list together with material from various countries of the Region suggests that storage areas might be provided on the scale shown in Table VII.

TABLE VII - STORAGE AREAS REQUIRED FOR MATERIALS AND TOOLS FOR VARIOUS INDUSTRIAL ARTS FIELDS

Field of Activity	*Storage sq.m.*	*% age of total laboratory area*	*Notes*
Woodworking	12	25	6 sq.m. open for timber 6 sq.m. for tools
Metal Working (fitting and sheet metal)	14	26	6 sq.m. open for bars and sheet 8 sq.m. for tools
Electricity/Electronics	8	23	
Spinning and Weaving	6	9	
Ceramics (pottery and clay craft)	12	24	6 sq.m. open for clay bin 6 sq.m. for tools
Rattan and bamboo work	12	30	6 sq.m. for bamboo 6 sq.m. for tools and material
Leather work	4	12	
Masonry	10	29	Brick and block storage outside sand open
Power mechanics	12	16	

Note: In all fields, storage for some tools is needed in the laboratory. The table refers to major and separate storage areas needed.

In a laboratory housing several fields of activity the median area for storage from Table VII will be 24%.

Storage areas actually provided in a selection of countries, expressed as a percentage of the laboratory area are shown in Table VIII.

TABLE VIII - STORAGE ROOM AREAS EXPRESSED AS A PERCENTAGE OF INDUSTRIAL ARTS LABORATORY AREAS

COUNTRY	*Storage area expressed as a percentage of Industrial Arts laboratory areas.*
Philippines	9
Hongkong	18
Cambodia	6
Ceylon	15
Singapore	16
Japan	33
U. K.	20
U. S. A.	15
South Africa	10

The median from Table VIII is 15%. Two factors should be considered in respect of Tables VII and VIII. If storage rooms are required in which a range of materials and tools are to be kept, then the areas provided in many schools in Asia, whilst no doubt adequate for the present, are unlikely to be large enough as more equipment and materials are added. Secondly, there is a trend in modern Industrial Arts laboratories to store all the commonly used tools in tool cupboards or cabinets (which can be locked) in the laboratory itself. This is why the storage room area for U.S.A. and South African schools is so small despite the considerable quantities of tools and equipment common in these countries.

Depending on the various tool storage policies adopted in the countries of the Region, it would seem that the provision should range from 15 to 24% of the floor area of a multi-field laboratory. Some of this may be in the form of open areas adjoining the laboratory (such as a wood store) and some in the form of lockable storage rooms as is shown in Figure 6 above.

4.04 *Other Spaces*

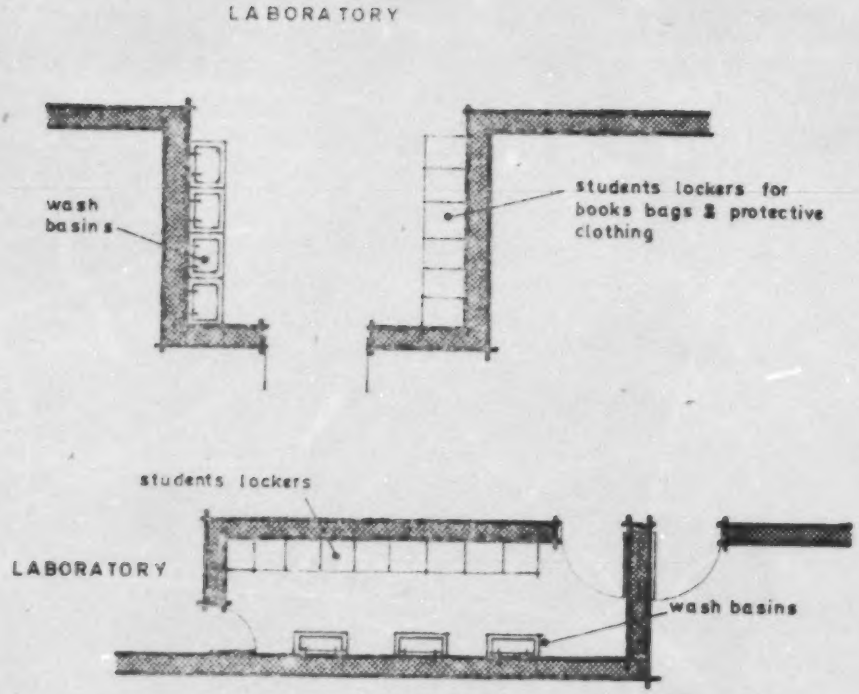
a) The teachers' room

If a teachers' room is provided, and for Industrial Arts teaching it is not a common unit of accommodation, then it can be quite small with just sufficient room for preparation of teaching material and storage of a limited number of books and personal tools/equipment. Two practices are commonly observed in this connection in the Region. First, where no teachers' room is provided, the store is often annexed and used as a combined store and office. Secondly, where storage space or cupboards are inadequate, the teachers' room, where it is provided, is used also for storage.

The sensible solution to the problem would appear to be provision of adequate storage space on the scale suggested in 4.03, above, and also of a modest but useful teachers' preparation room. An area of about 9 sq. metres would be sufficient for one or two teachers. The walls between the room and the laboratory should be glazed so that, even when the teacher is in the room he can still see what is going on in the work space outside.

b) Toilet and lavatory facilities

Industrial Arts activities cause frequently soiling of hands and clothes and there is a need, not only for protective clothing for the children (and for its storage) but also for washing facilities. If these are available reasonably close by in another part of the school then it will be cheaper to use them. However, working with oils, fats and greases in a metal shop requires special cleaning agents for washing which are not normally available in such toilets. Handwashing facilities can thus best be provided, as they are in industrial situations, adjacent to or forming part of the workshop. Figure 9 suggests two possible arrangements. The first has the virtue that, as it is in a lobby, students are reminded of the need to wash and being open to view the basins are more likely to be kept clean. The second arrangement, used in Cambodia, enables the students bags to be left in a locked room during the lesson. About 7 or 8 square metres provides adequate space for handwashing and changing facilities.



HAND WASHING & CHANGING FACILITIES

figure. 9.

4.05 Services

The most important aspect of the provision of services to multi-field laboratories is the need for complete flexibility. Laboratory layouts may be changed from time to time; fields of activity (somewhat less frequently) may change; the curriculum content may change.

The temptation that faces most designers is that of attempting - quite laudably - to arrange service layouts in consultation with the inspectors and teachers who are to be concerned with the laboratory when it is constructed. Educators are inevitably and correctly concerned with a design solution that meets their own special requirements. The designer has, of course, to see that their needs are satisfied. However, in creating a design for a building that may have to satisfy the needs of numerous and unknown inspectors and teachers who will use the building during its life of perhaps 40 or 50 years, he has to look somewhat further ahead than the present and design a building of which the main characteristic is adaptibility.

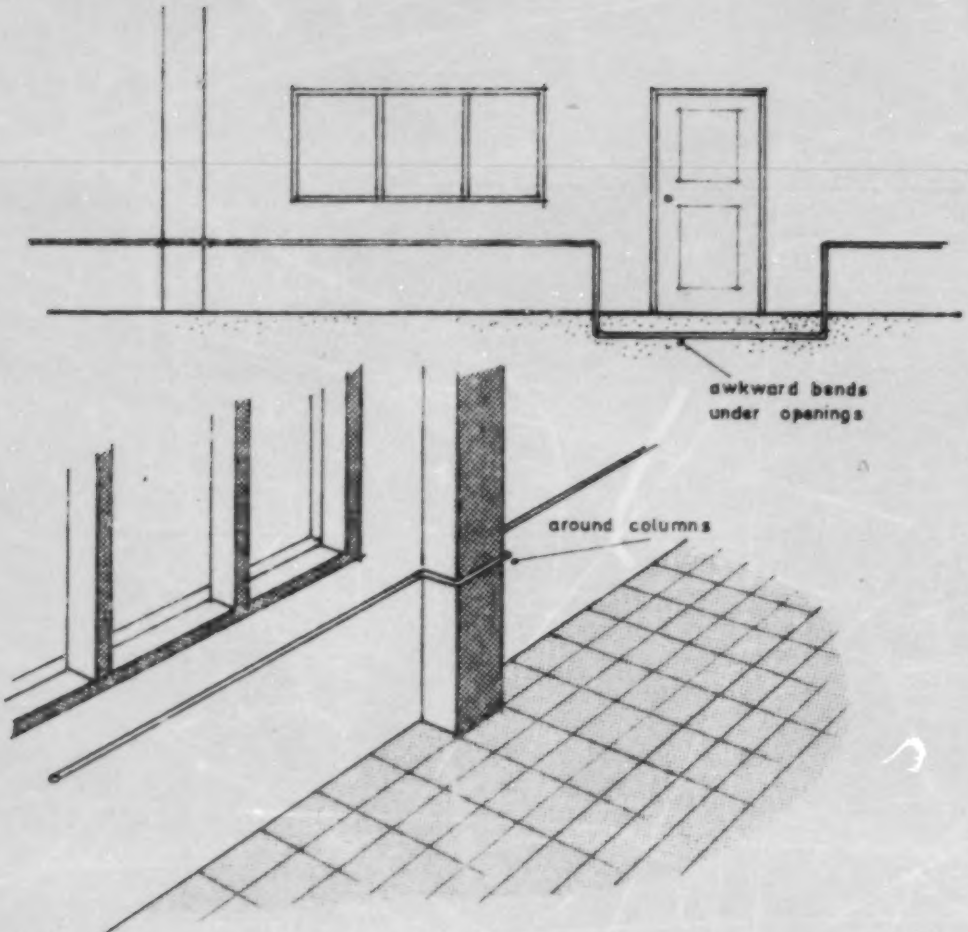
The point again needs emphasis in relation to the urban/rural situation. In many rural areas in Asia, at the present time, mains services are not available. There is no doubt, however, that with rapidly increasing electrification, most permanent buildings built in the rural areas today will require modification to receive mains power and water in the not too distant future. Woodwork and metalwork laboratories in remote country areas will be equipped with simple machinery for sawing, planing, shaping and turning and ceramics laboratories will have mains water supply and small electric kilns.

Thus, whether the laboratory is built in a developed or undeveloped area of Asia, its structure and construction must be such as to permit of the easy introduction and internal distribution of services.

This implies careful attention to the selection of structure of both walls and ceilings, for services in the floor are immovable and thus not desirable, however intricate the grid layout that is suggested.

As far as walls are concerned, certain problems of distribution present themselves. Openings have to be passed and, where there are columns, awkward bends are caused (Figure 10).

The best place, therefore, is probably the ceiling. Ceilings rarely have openings and, where they do, they can be bridged without impeding traffic. The problem of beams can be overcome by a suspended grid. The preferred structure is one which per-



DISADVANTAGES OF WALL FIXING OF SERVICES
figure. 10

mits of easy suspension such as a framed roof of wood or metal, and to which fixing is easy (Figure 11).

In a laboratory of 9m. width, service lines indicated in Figure 11(a) will allow outlets to be fixed to machines or equipment at virtually any point.

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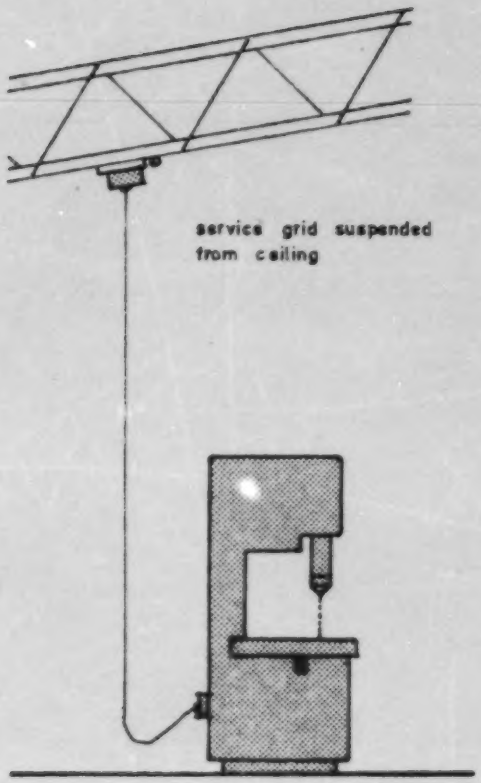
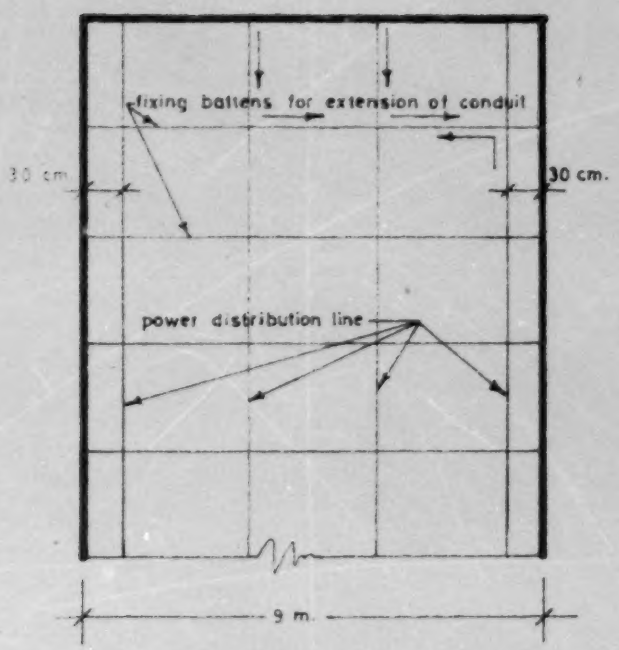


SERVICE AT CEILING LEVEL
figure. 11



PLAN LOOKING UP

figure. 11a

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CHAPTER - 5

ERGONOMICS

5.01 General

Ergonomics is concerned with ways of improving the performance of tasks through detailed attention to the design of the environment. In industry this is of considerable importance, for improved performance leads to improved production. Whilst production, *per se* is not one of the purposes of Industrial Arts education, an understanding of industry and of the factors affecting industrial production are one of its main aims. Ergonomics is thus a topic which has an important bearing on the teaching and learning situation in this (and other) areas.

The aspects of ergonomics which are relevant in this context are layout of equipment, design of seating, thermal comfort, noise and the visual environment, all of which are touched upon in the following sections.

5.02 Layout of Equipment

The more common meaning ascribed to the term "layout" in works on ergonomics is the detailed arrangement of industrial machines - the sizes and design of dials, the positions and sizes of control panels, wheels, switches and the like. In the context of this study, however, ergonomics is considered in relation to the positions of equipment to achieve most effective performance, mainly in respect of the teaching and learning function, but also for improved performance of operations leading to production.

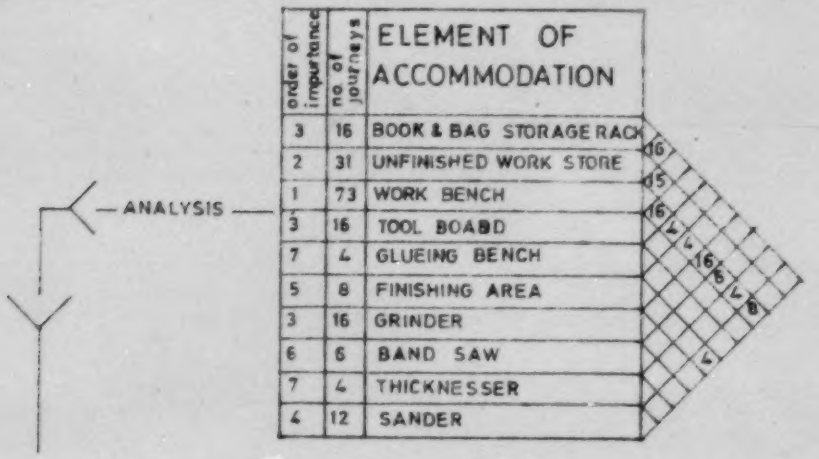
As far as teaching and learning are concerned, the following activities can be foreseen:-

i) Planning work by the student;
ii) Discussion of plans with the teacher;
iii) Execution of work by the student and occasional discussion with the teacher at critical phases in the operation;
iv) Evaluation of work by students and teacher.

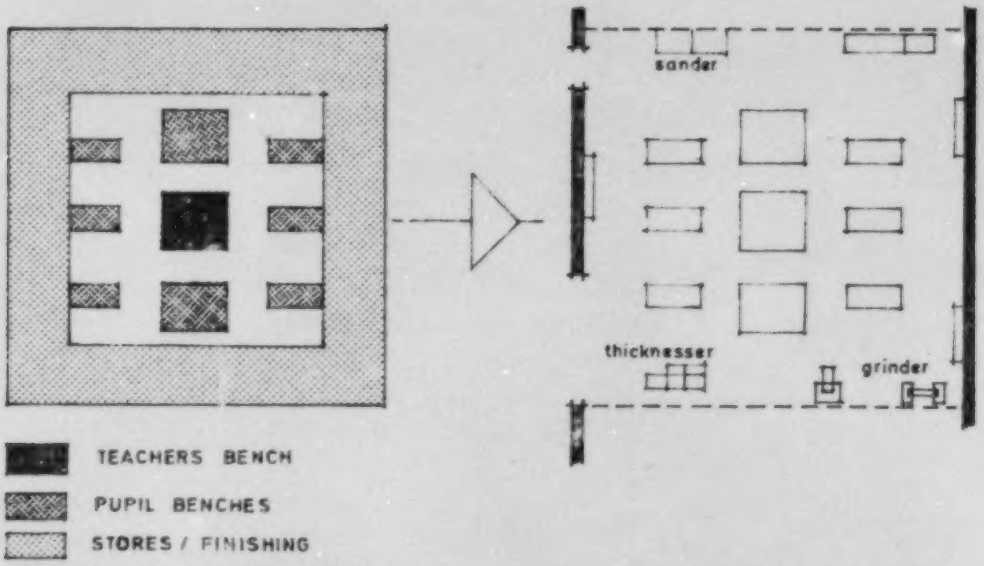
These activities include two main elements:-

a) the normal production process;
b) the intermittent breaks from production for joint discussions/demonstrations with the teacher.

The situation can be analysed for conventional teaching by activity fields through association charts. Figure 12 shows pos-



order of importance	no. of journeys	ELEMENT OF ACCOMMODATION
3	16	BOOK & BAG STORAGE RACK
2	31	UNFINISHED WORK STORE
1	73	WORK BENCH
3	16	TOOL BOARD
7	4	GLUEING BENCH
5	8	FINISHING AREA
3	16	GRINDER
6	6	BAND SAW
7	4	THICKNESSER
4	12	SANDER



theoretically desirable location of teachers table and students benches

resultant final arrangement of wood work shop

ANALYSIS OF WOODWORKING ACTIVITIES LEADING TO OPTIMUM LABORATORY LAYOUT FOR MINIMUM MOVEMENT

figure. 12

sible movements in a woodworking laboratory for 10 double periods during which all students are working on similar projects.

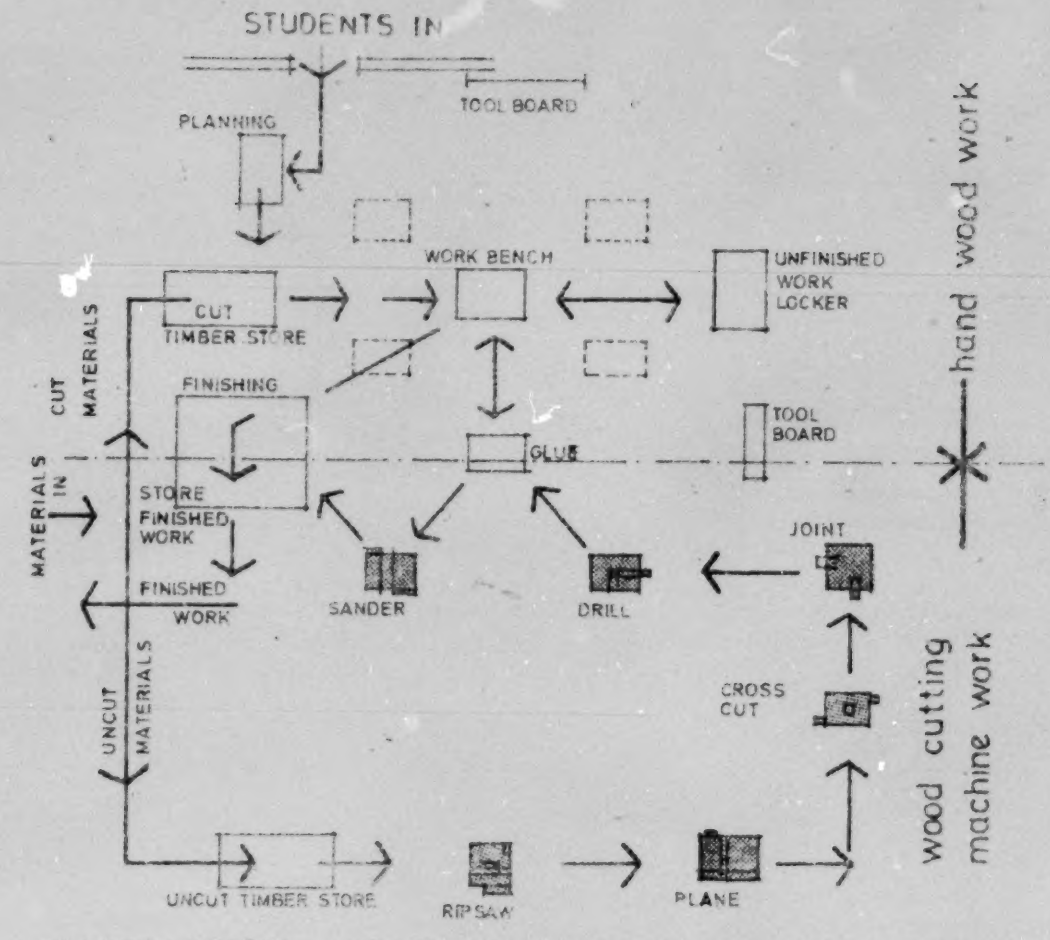
The association chart which is the first diagram in Fig.12 suggests from the numbers of journeys made and shown in the second column that, for discussion and demonstration involving minimum movement of teacher and students the teacher's bench is best located in the centre of the most commonly used work area. This, the association chart shows to be the students work bench area. Other accommodation elements are of lesser importance and can be located around the periphery of the work benches. The situation is indicated diagrammatically in the second diagram of the figure and one of many possible solutions shown in the third diagram.

Other situations may result in more complex solutions. In the case of the Industrial Arts syllabus for Pakistan, wood cutting machines are included among the list of equipment designed to give students different experiences in the field of woodworking. Machinery used for woodworking involves a flow process and the students will obtain an insight into such processes and their production possibilities if the machines are arranged in logical sequence. The design problem is to arrange for this activity in the same space as is used for hand wood working. Figure 13 suggests diagrammatically one of many possible answers to the problem.

A multi-field laboratory is not, however, confined to woodworking. In one space there may be activities as varied as ceramics and weaving, leather and metal work. How can these best be arranged to provide optimum conditions for teaching and learning?

The answer to the question suggests at once the traditional arrangement of spaces within the multi-field laboratory in watertight compartments. The multi-field laboratory, however, provides an excellent opportunity to break away from this concept of separate fields and separate spaces and to emphasise the unity of rather than the division between the fields.

Several possibilities present themselves in this context. First, it may be useful to link metal, electricity and motor mechanics work in one area. The power units and other parts of vehicles provide a wide range of experience in all of these three fields. Secondly, activities common to all industries may be linked in concept areas such as cutting, jointing, finishing. A third alternative is to regard all of Industrial Arts as having a construction function and to arrange the equipment and furniture



DIAGRAMMATIC LAYOUT OF COMBINED HAND WOOD-WORKING AND WOODCUTTING MACHINE WORKSHOP

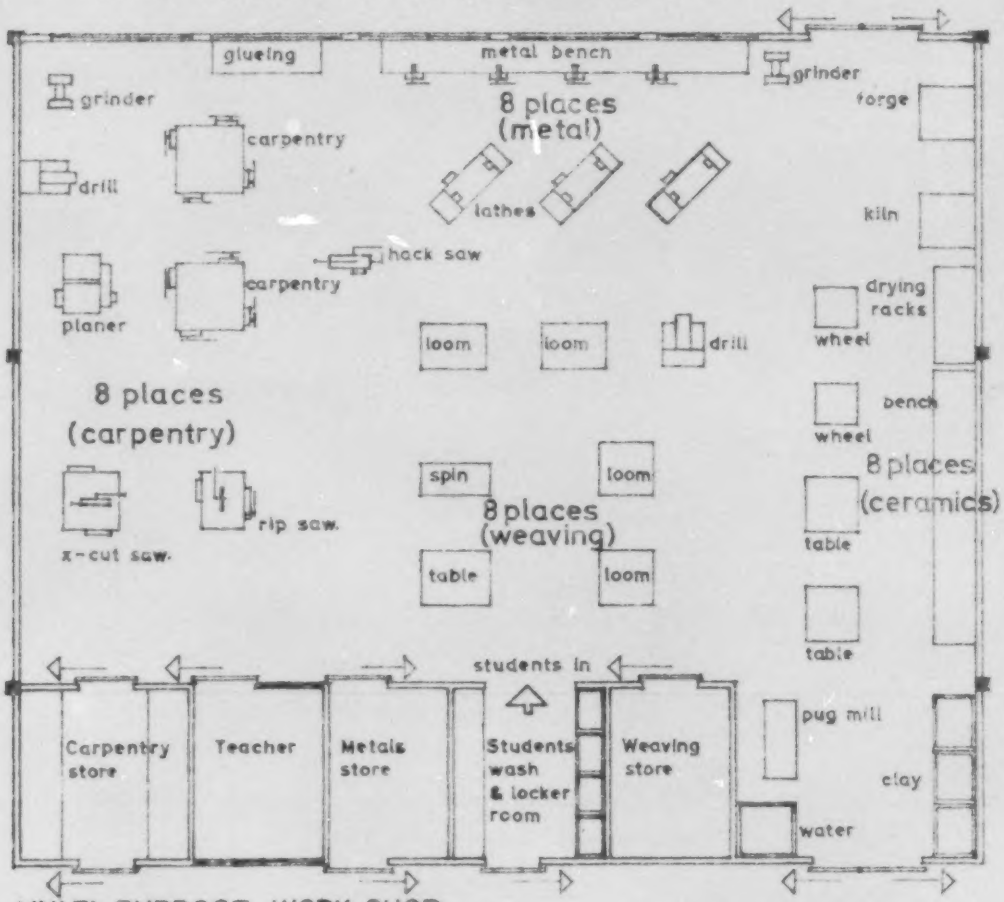
figure. 13

in the space in such a way that the concept is emphasised. Students would then explore ways to construct projects using a variety of materials such as plastics, wood, reconstituted wood, metals such as aluminimun as well as electricity and the like. There is also the possibility of the introduction of topics such as power technology in which fuels, electricity, solar energy etc. can be considered in relation to projects requiring hand or machine skills.

It is, of course, realised, that in most Asian countries, none of these approaches to providing experience to second level studies have, in fact, been adopted. The reason why they have

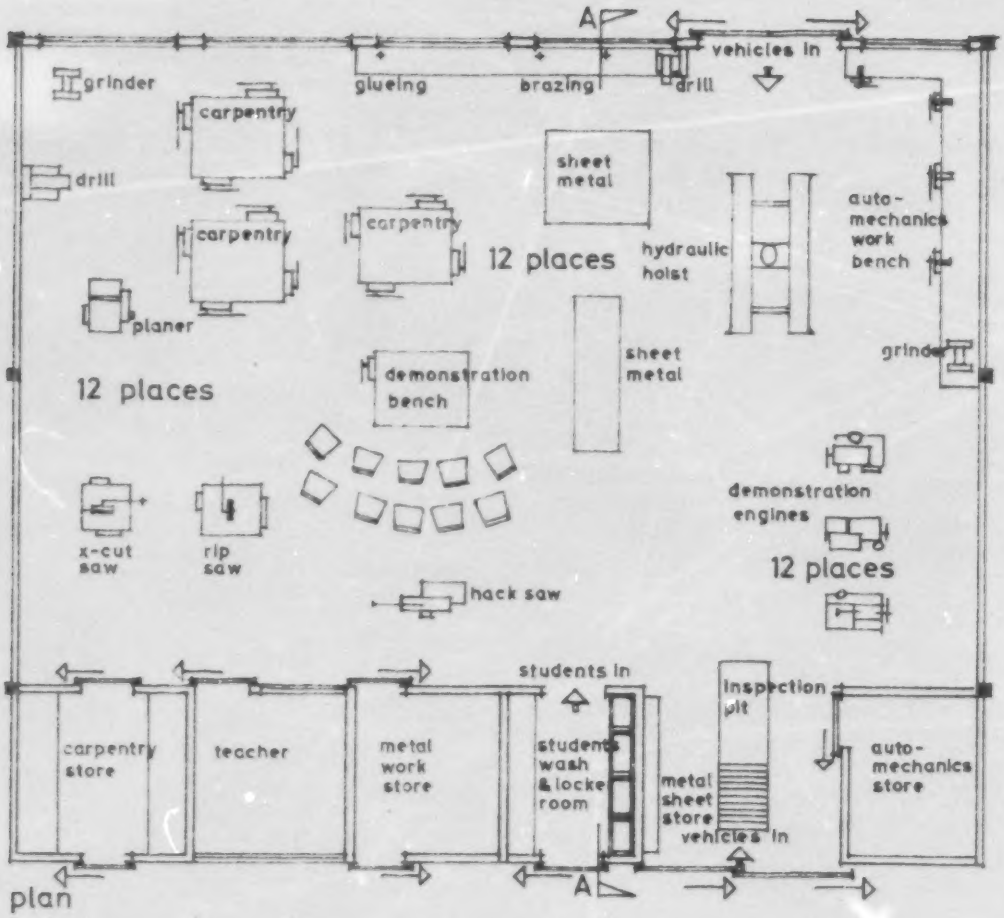
been mentioned at all is that architects and designers, in providing permanent buildings for present activities, need to bear in mind that education is subject to constant change and the fact that some of the approaches to Industrial Arts, outlined above, have long been adopted in other parts of the world suggests that spaces for teaching and learning should not be too closely tailored to present curricula. Of all areas of education this is the one most likely to alter in coming years and changes, when they come, will be the easier in adaptable rather than rigidly defined working spaces.

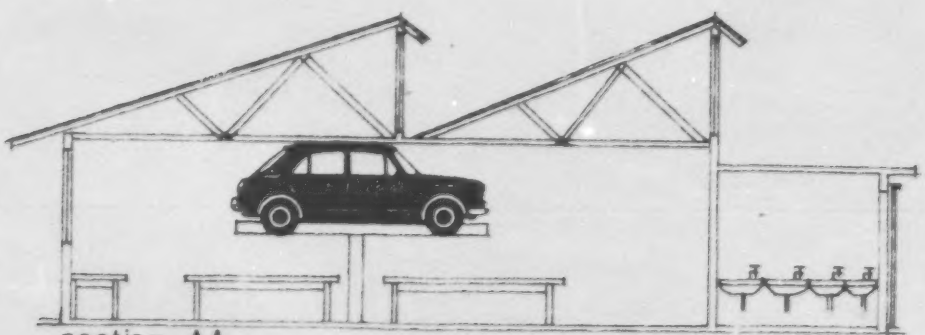
As far as the present position is concerned, some of the ways in which the furniture and equipment for a common combination of Industrial Arts fields can be arranged are shown in Figures 14 and 15. The principles of layout evident in these fields are equally applicable to any other combinations.



MULTI-PURPOSE WORK-SHOP
(wood, metal, ceramics, weaving)

figure 14





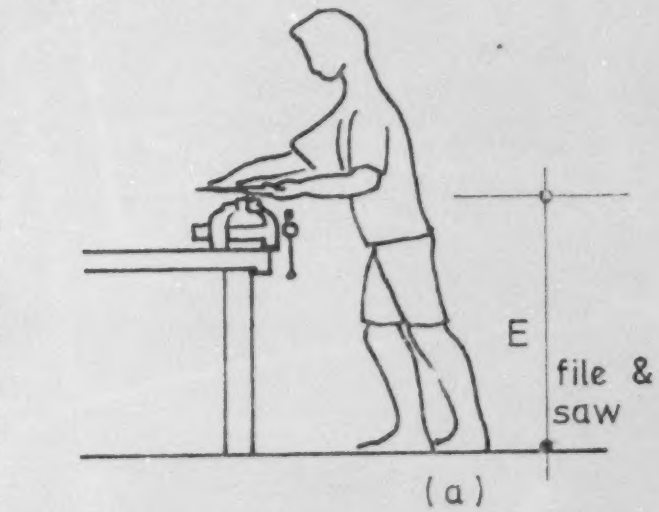
section AA

MULTI-PURPOSE WORKSHOP
(carpentry, sheet metal, auto mechanics) figure 15

5.03 Anthropometrics and Workshop Benches

Three dimensions are critical in the design of work benches Two of these, that is the length and the breadth, need to be settled locally in relation to the nature of the students' work. For example, in woodwork the students may be making items of furniture or it may be the practice to construct smaller models. Different lengths and breadths of table will be required for each of these local situations. The third and perhaps the most important dimension, however, is the working height of the bench. Many operations depend for their success on the correct relationship of the parts of the body to the task.

For example, successful filing of metal requires that the hand and forearm holding the handle of the file moves the file backwards and forwards always parallel to the floor. The surface of the metal to be filed must thus be fixed exactly at the height of the students' elbow if the operation is to be performed properly. Figure 16a illustrates this point. Similarly, marking out sheet metal requires the student to be able to get 'over' the task. Figure 16b illustrates this and it can be concluded that the same height of bench can be used for filing and sheet metal provided that the vice height is correctly adjusted.



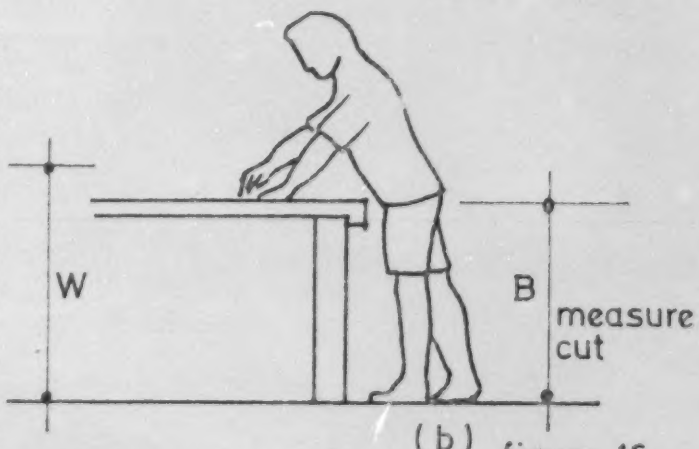


figure 16

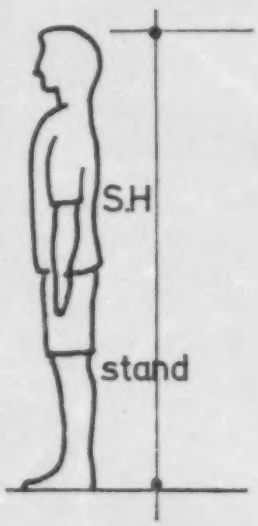
Table IX shows suitable metalwork bench heights for children aged from 12 to 17 years.

TABLE. IX

METALWORK

BASIC BODY DIMENSIONS & HEIGHTS OF WORKING SURFACES

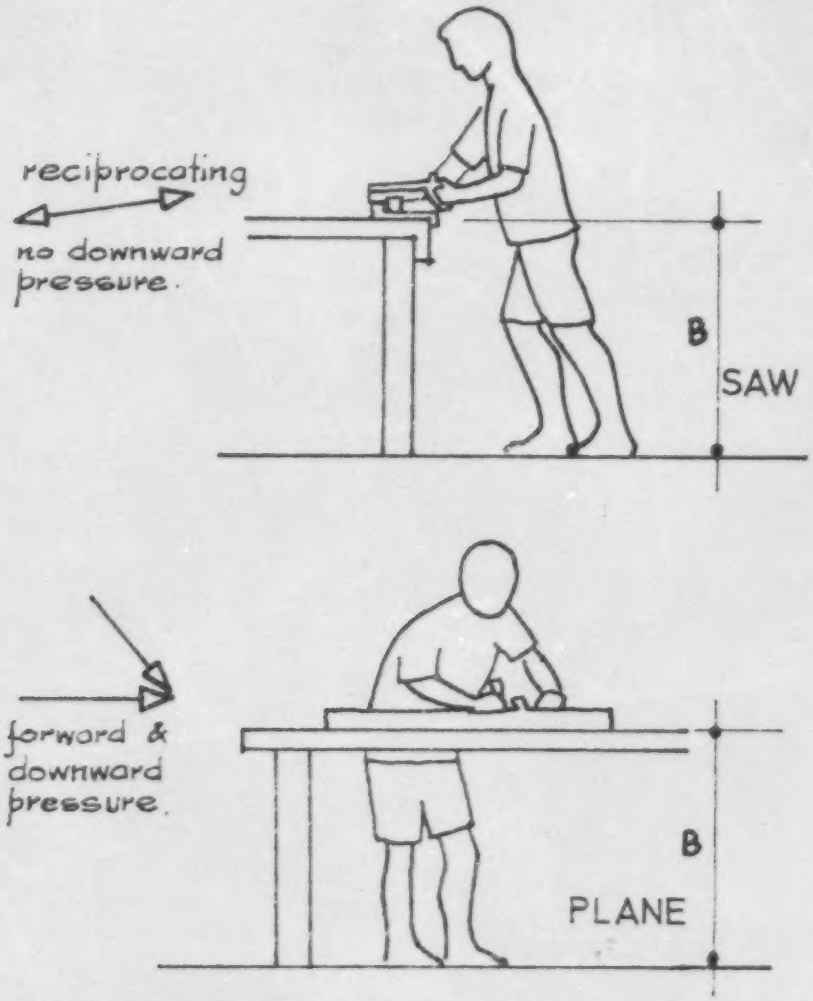
age in years	mean height	elbow & vice top height	waist height	bench height *
	S.H (cms)	E (cms)	W (cms)	B (cms)
12	136	81	74	64
13	141	89	77	72
14	146	92	80	75
15	152	96	83	79
16	157	99	85	82
17	161	101	87	84



* assuming distance from top of vice jaws to bench top is 17 cms. for other vice sizes an adjusment will be needed in bench height.

NOTE. for dimensions E, W & B see figure. 16

In woodworking, the situation is slightly different as the vice top will be in the same plane as the surface of the bench. Again the critical height is that of the elbow. Planing requires slight downward pressure and thus the desire bench height is somewhat below elbow height as is indicated in Figure 17 which also shows the posture for sawing.



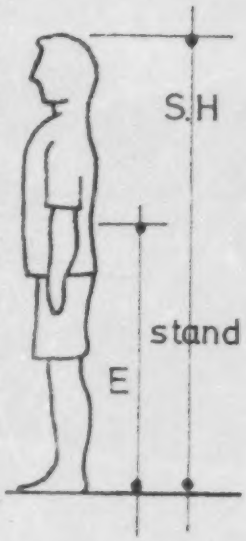
POSTURES FOR SAWING AND PLANING IN WOODWOORKING figure. 17

Table X gives bench heights for wood working for children of ages ranging from 12 to 17 years.

TABLE X WOODWORK BENCH

BASIC BODY DIMENSIONS & HEIGHTS OF WORKING SURFACES

age in years	mean height	elbow height	bench height
	S.H (cms)	E (cms)	B (cms)
12	136	81	71
13	141	89	79
14	146	92	82
15	152	96	86
16	157	99	89
17	161	101	91



Figures, 18,19 and 20 show similar data for electricity, general crafts and technical drawing whilst Tables XI, XII and XIII give suitable bench heights.

TABLE. XI ELECTRICITY

BASIC BODY DIMENSIONS AND HEIGHTS OF WORKING SURFACES

age in years	mean height	bench height sitting	bench ht. sitting / standing	seat height	
	S.H (cms)	B (cms)	B.S (cms)	A	C
12	136	60	77	38	55
13	141	63	80	39	56
14	146	65	83	41	59
15	152	68	86	42	60
16	157	70	89	44	63
17	161	72	92	45	65

* NOTE. there should be no drawer or other obstruction under a surface. correctly located for sitting.

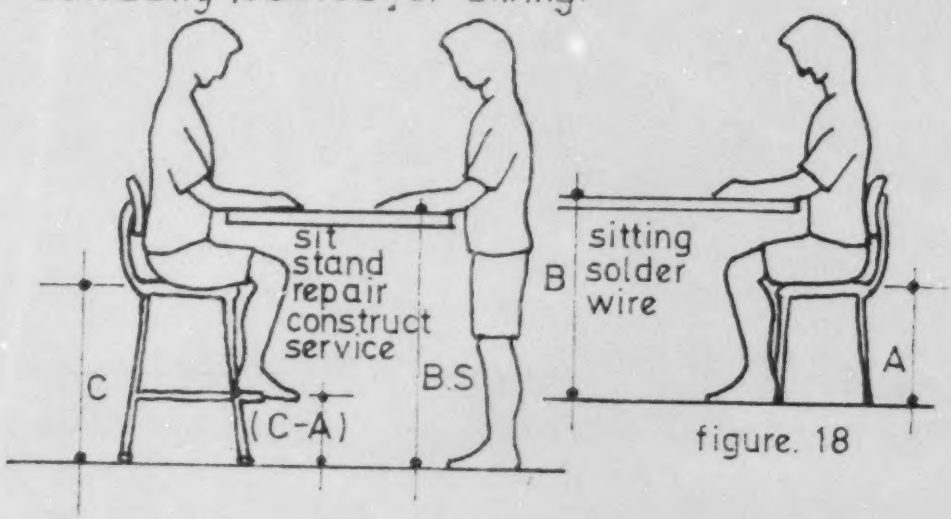


figure. 18

TABLE. XII GENERAL CRAFTS

BASIC BODY DIMENSIONS AND HEIGHTS OF WORKING SURFACES

age in years	mean height	bench height sitting	bench ht. sitting / standing	seat height	
	S.H (cms)	B (cms)	B S (cms)	A	C
12	136	60	77	38	55
13	141	63	80	39	56
14	146	65	83	41	59
15	152	68	86	42	60
16	157	70	89	44	63
17	161	72	92	45	65

* Note there should be no drawer or other obstruction under a surface correctly located for sitting

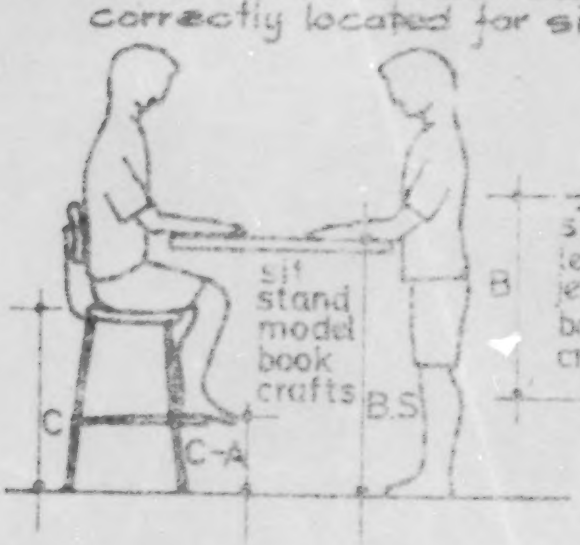


figure. 19

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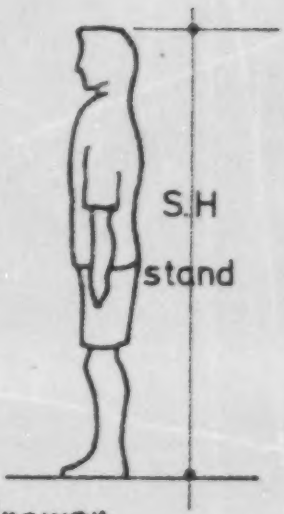
TABLE XIII TECHNICAL DRAWING

BASIC BODY DIMENSIONS AND HEIGHTS OF WORKING SURFACES

age in years	mean height	table height (front)	seat height
	S.H(cms)	B (cms)	A (cms)
12	136	60	38
13	141	63	39
14	146	65	41
15	152	68	42
16	157	70	44
17	161	72	45



* NOTE. there should be no drawer or other obstruction under the table surface. A flat surface at the side of the inclined work surface maybe provided for instruments.

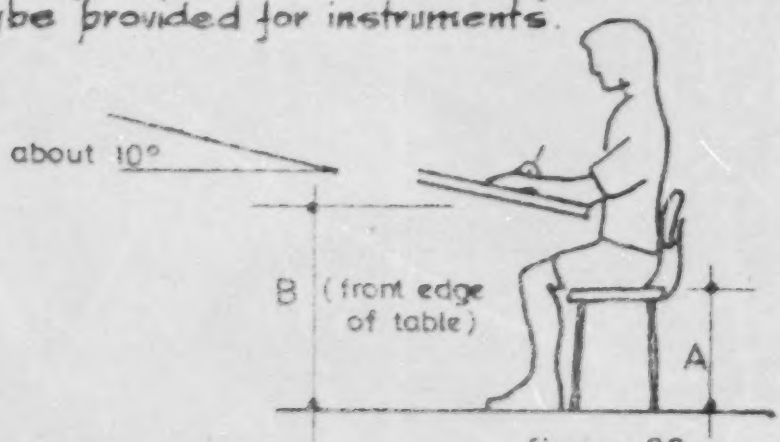


figure. 20

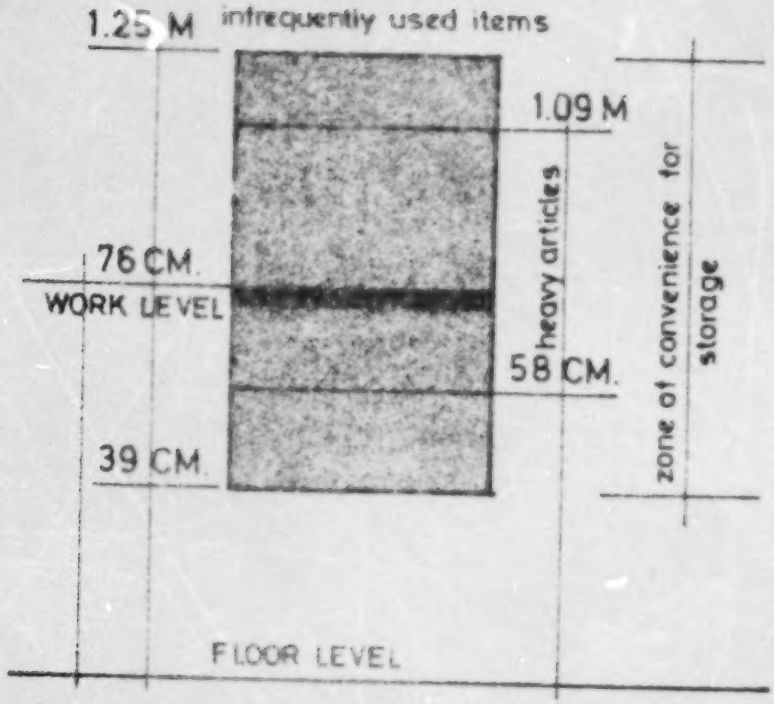
In giving tables of height in relation to age in the foregoing five figures, it is not suggested that every laboratory has six sizes of benches. This would be quite unreasonable. What is suggested is that if, for example, the grades using the laboratory are aged 12,13 and 14 years, then the bench height would be standard for 13 year olds. Similarly, whatever the age range in a particular situation, the bench selected would be for the median age of those using it.

5.04 Anthropometrics and Storage

Storage may be regarded as dead or live storage and the items to be stored as heavy (requiring two hands to lift) or light (liftable in one hand). Dead storage is for items that are very infrequently used and on which the effort of lifting is thus rarely exercised. It can thus occupy spaces in which one would not normally put heavy items that are frequently used. As far as live storage is concerned, it should be such that heavy items for which it is necessary to use two hands in handling, are stored at or about waist height; lighter items can be stored at levels further away from the waist level and this may involve bending or stretching. Storage below about 40cm from the floor involves about twice as much energy expenditure in bending than would be required for storage higher up. Thus no storage should be provided *below* this level except for very infrequently used items. Storage below 40cm from the floor can, moreover, not be seen and is difficult to clean. It should thus not be provided in the laboratory at all - only in the lockable store.

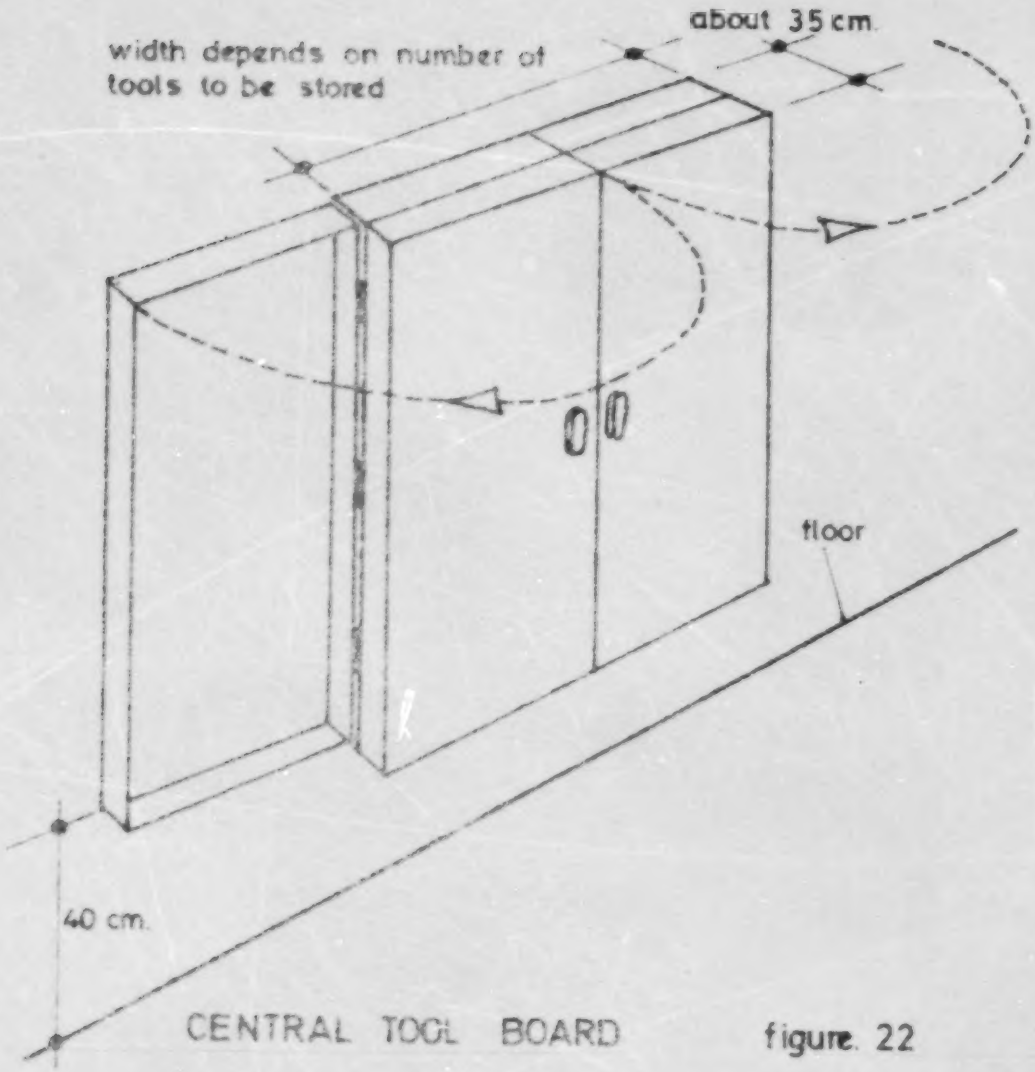
The height to which students age 14 can conveniently reach is shown in Figure 21. Storage above this level is possible but, for the same reasons that low level storage is to be avoided, high level storage should not be provided in the laboratory.

Minimum energy expenditure, visibility for cleaning and counting and, of course, sufficient depth or length for the items to be stored are the guiding principles in providing cupboards, shelves and other storage units. Figure 22 illustrates an example of a laboratory storage unit for tools such as is now commonly in use in the Region. This unit, known as the "tool board" is at a usable height and has the advantage that it contains a number of commonly used tools, sufficient for a group of students. With such a unit, there is no need for storage at the bench which is uneconomical in tool utilization. Storage at the bench means storage at the side of or under the bench and as the average



ZONES OF CONVENIENCE FOR STORAGE
figure. 21

bench is only about 60 to 70 cms from floor level, tools stored under it will be very close to the 40cm datum, below which excessive energy is required to reach them.



CENTRAL TOOL BOARD figure. 22

5.05 *Visual Environment*

Two conditions have to be satisfied; there must be the correct level of illumination (measured in f.c. or lux) on the task and, secondly, there must be no visual discomfort due to glare.

As far as illumination levels are concerned, a general rule is that the finer the task, the better it requires to be seen and thus, the higher the level of illumination needed. Studies have shown (Mc Cormick & Niven, in Murrells, Ergonomics) that "working with a task requiring speed and precision, there was a significant decrease in errors when the illumination was increased from 5 to 50 lm/ft.sq. When the illumination was further increased to 150 lm/ft.sq. there was a slight but non-significant increase in errors". The subject is made complex by other factors such as the size of the task, brightness contrast and glare.

In general and where electric light is not available then as much daylight as possible should be admitted to the laboratory.

In designing for maximum daylighting (and obtaining a maximum of internal reflected light through light coloured decorations) a variety of illumination levels will be obtained in the laboratory - the high levels near the windows, low levels furthest from the windows. Work stations can thus be arranged in relation to this spectrum and to the needs for high or low illumination on the task. Methods for design for daylight are given in the Institute's School Building Digests No.10 and 11.

3.06 *Thermal Comfort*

Much of Industrial Arts activity produces body heat. In hot-humid climates this can best be removed by a system of natural ventilation by which air currents from external breezes are introduced into the laboratory *at body level*, not at ceiling level as is so commonly the case. Fixed grilles, louvres and pierced bricks or blockwork are the easiest means to achieve this. For hot, dry climates the answer is not so much in construction as in time tabling. Industrial Arts periods in hot, dry areas should always be arranged as early as possible in the morning. Of course, if full utilization of the laboratory is desired, it will be in use throughout the day in which case thermal insulation providing sufficient time lag to prevent radiant heat from penetrating the building or, alternatively, sunshading of walls, gives a cool laboratory.

The subject is discussed at greater length in respect of hot-dry climates in the Institute's Technical Paper no.1.

7 Noise

Laboratories are usually, as far as the rest of a school is concerned, sources of undesired sound. They can best be housed in separate buildings, somewhat away from the main teaching accomodation for two good reasons:-

i) To reduce noise (sound levels decrease inversely as the square of the distance from the source);
ii) To allow of laboratory expansion.

The level of sound produced under normal working conditions may exceed 90dbA and to achieve a reduction to the acceptable 35dbA, intrusive sound level in a classroom suggests the two elements of accommodation should be located at least 50 metres apart from each other and that planting or another obstruction to sound transmission such as a wall would be useful too.

ANNEX - I

METHOD OF CALCULATING NETT PER PLACE AREA FOR ACTIVITY FIELDS

a) Woodwork
b) Metalwork (fitting and sheet metal)
c) Electricity
d) Spinning and weaving
e) Ceramics
f) Rattan and bamboo work
g) Leather work
h) Masonry/Building construction
i) Power mechanics/Motor mechanics

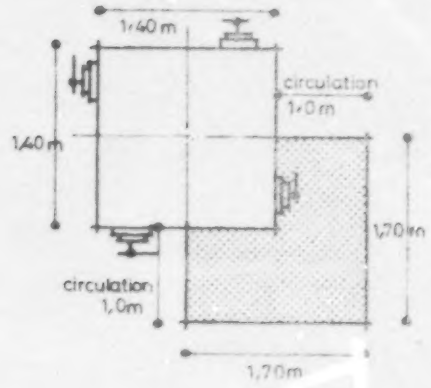
ANNEX - I

Fig.(a)

PER PLACE AREA FOR WOODWORK

Element	Area in sq. m.

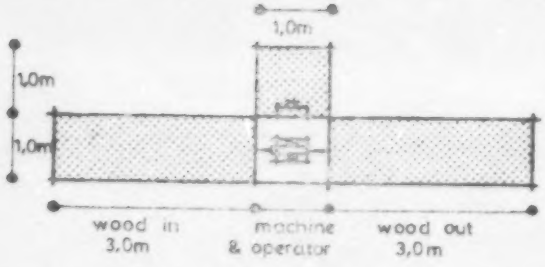
i) Individual space



per place area
= 2.90

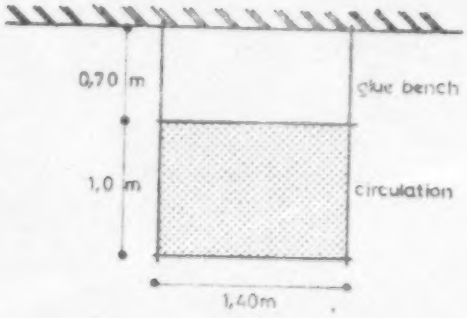
Note: in woodwork a bench space of this type provided for each student.

ii) Area for common activities (assume one wood cutting machine, one glue bench.)



per place area
= 1.00

Note: Total area / 8 places



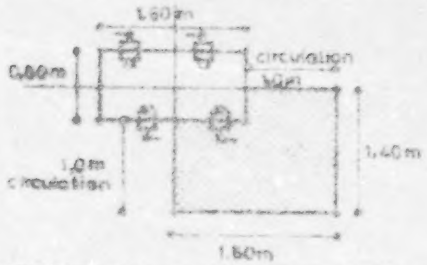
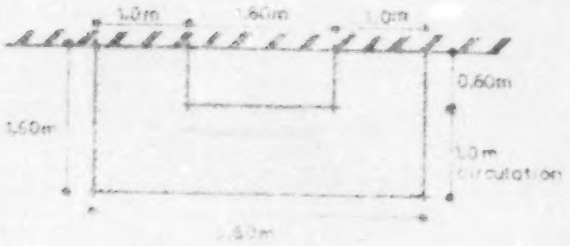
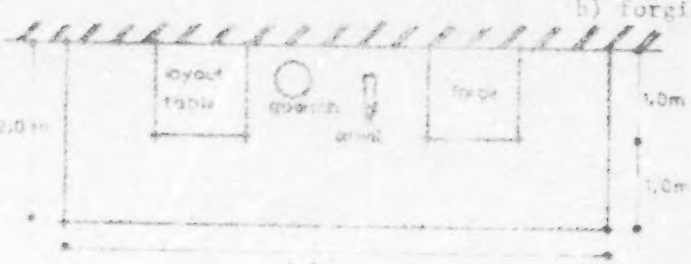
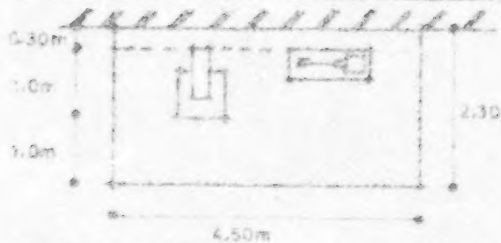
per place area
= 0.30

iii) Area for laboratory total storage - per place	=	0.25
iv) Area for demonstration - per place	=	0.25
TOTAL PER PLACE AREA	=	4.70

ANNEX - I

Fig.(b)

PER PLACE AREA FOR METAL WORK
(Fitting and Sheet Metal)

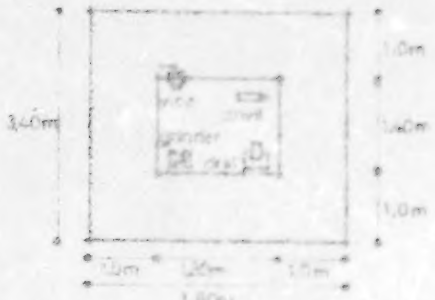
Element	Area in sq. m.
i) Individual Workspace (fitting) 	per place area = 1.25 *Note:* In metal work only four places for fiting per group of 8 students.
ii) Areas for common activities a) Sheet metal 	per place area = 0.75 *Note:* Total area / 8 places
b) forging 	per place area = 1.50
c) machines (lathe and drill press) 	= per place area = 1.30
iii) Area for laboratory tool storage - per place = 0.25	
iv) Area for demonstration - per place = 0.25	
TOTAL PER PLACE AREA = 5.30	

ANNEX - I

Fig.(:)

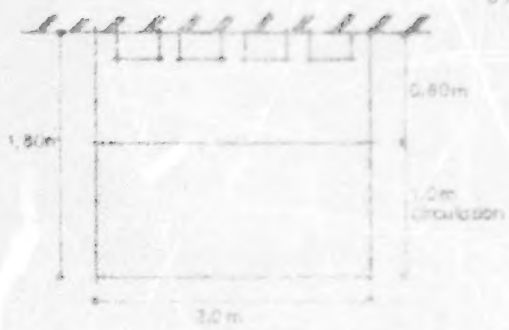
ISE PLACE AREA FOR ELECTRICITY

Element	Area in sq. m.
(i) Areas for common activities a) General work bench	



per place area = 1.60

Note: Total area / 8 places

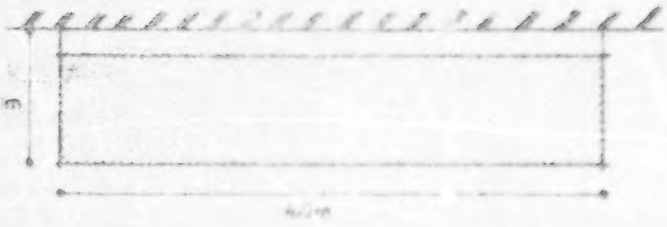


b) Test bench with the instruments and parts panel

per place area = 0.45

Note: Total area / 8 places

c) Elementary wiring board



per place area = 0.50

(ii) Area for laboratory tool storage	- per place	= 0.25
(iv) Area for demonstration including spaces for display panels	- per place	= 0.50
	TOTAL PER PLACE AREA	= 3.30

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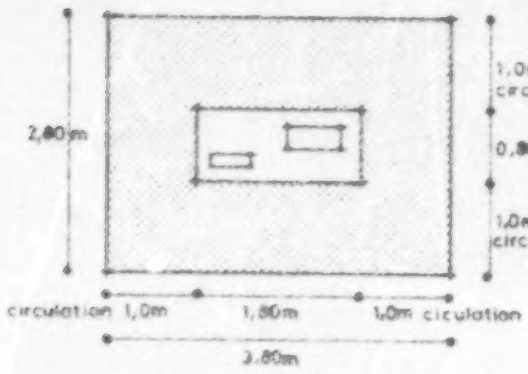
ANNEX - I

Fig.(d)

PER PLACE AREA FOR SPINNING AND WEAVING

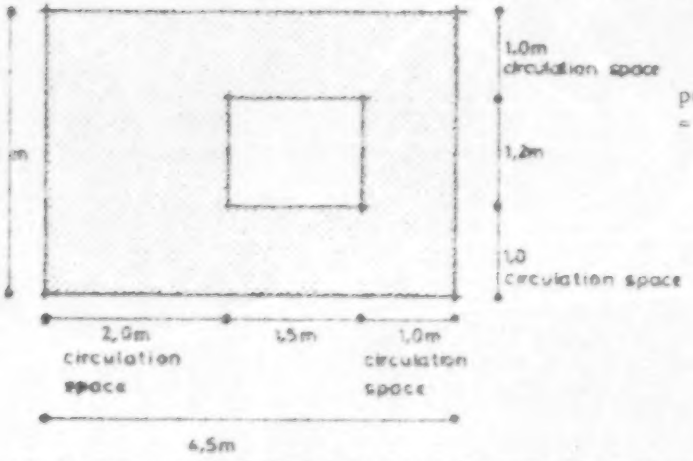
Element		Area in sq. m.
ii) Area for common activities	a) Box and table loom unit	



per place area = 1.35

Note: Total area / 8 places

b) Pit fly shuttle loom



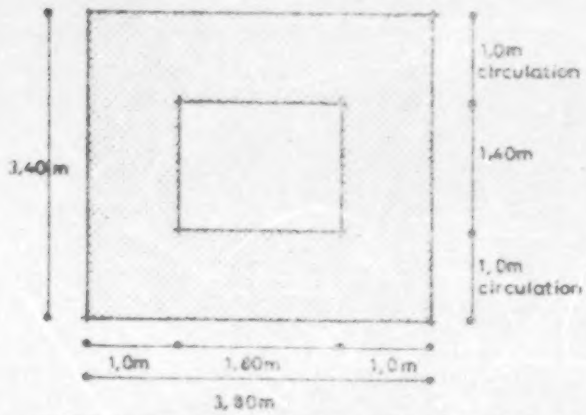
per place area = 1.8

c) Frame fly shuttle loom.	areas as (b)	=	1.8
d) Spinning wheels (1.0 x 0.5c), carders etc.	per place area say	=	1.5
iii) Area for laboratory storage	per place	=	0.25
iv) Area for demonstration and drawing table	per place	=	0.50
	TOTAL PER PLACE AREA	=	7.20

ANNEX - I Fig.(e)

PER PLACE AREA FOR CERAMIC (POTTERY & CLAY CRAFT)

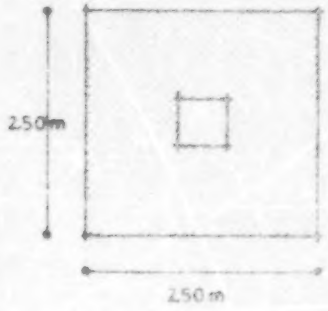
Element	Area in sq. m.
ii) Areas for common activities	a) General work tables (2)



per place area = 3.20

Note: Total area / 8 places

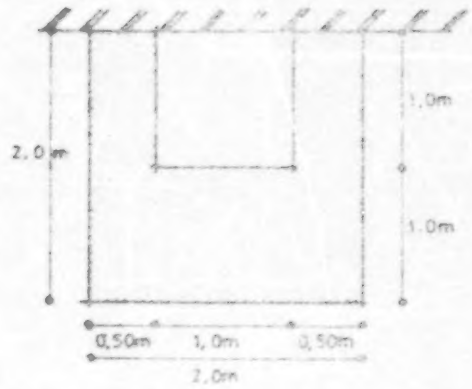
b) Potters wheels (2)



per place area = 1.55

Note: Total area / 8 places

c) Kiln



per place area = 0.50

Note: Total area / 8 places

iii) Area for laboratory storage including clay bins	- per place = 0.50
iv) Area for demonstration	- per place = 0.25
	TOTAL PER PLACE AREA = 5.00

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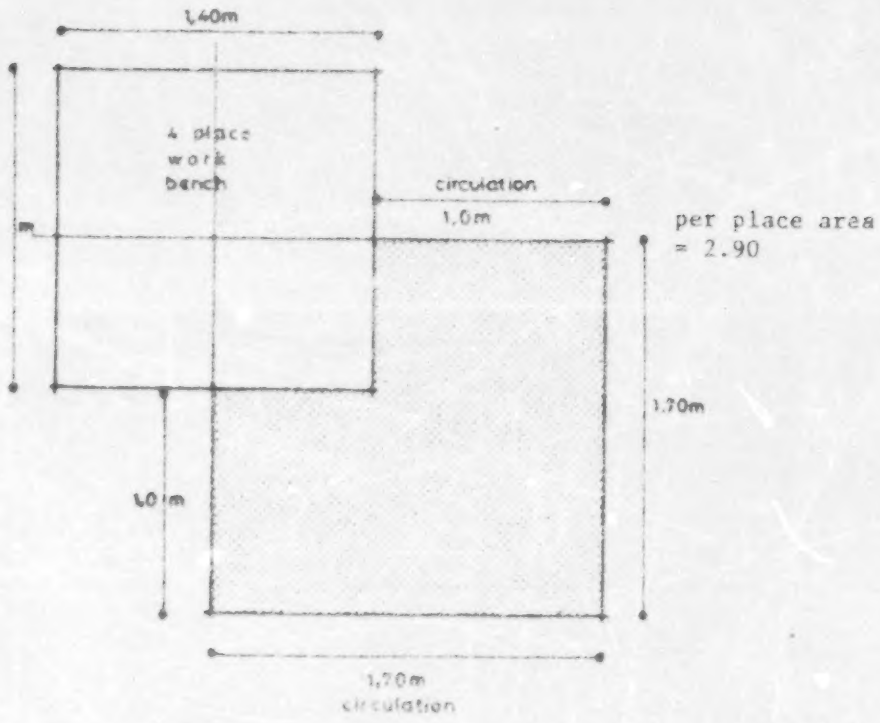
ANNEX - I

Fig.(f)

PER PLACE AREA FOR RATTAN AND BAMBOO WORK

Element	Area in sq. m.

i) Individual work space



ii) Area for common activities	-	for sawing, splitting, scraping and weaving larger items.	= 0.50
iii) Area for laboratory tool storage	-	per place	= 0.25
iv) Area for demonstration	-	per place	= 0.25
		TOTAL PER PLACE AREA	= 3.90

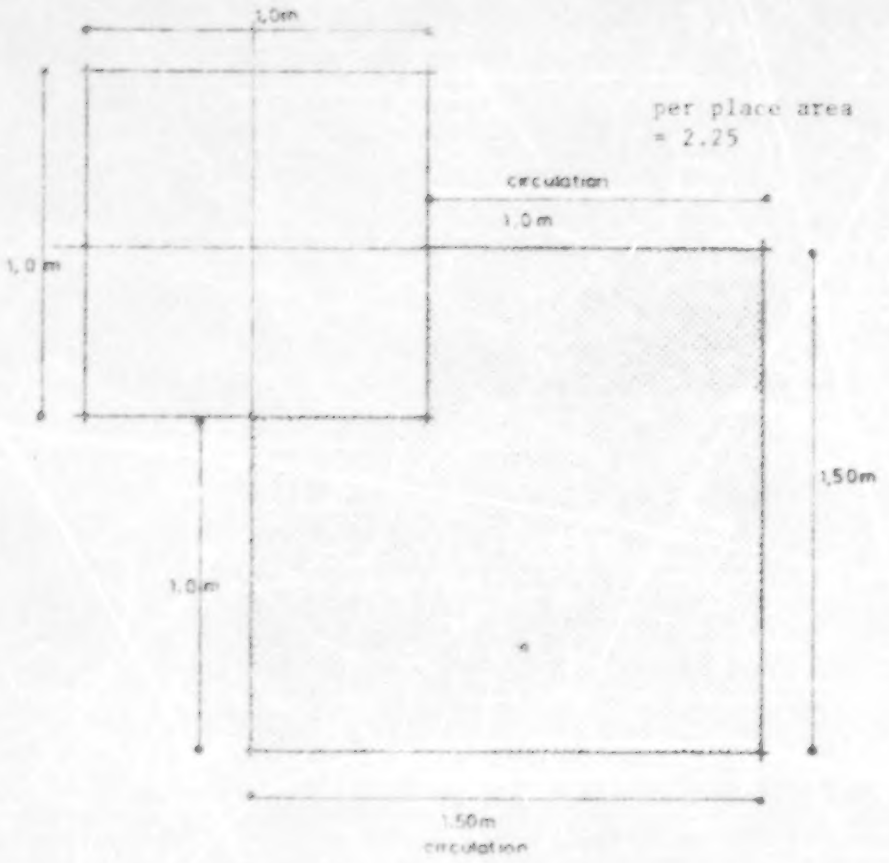
ANNEY - I

Fig.(g)

PER PLACE AREA FOR LEATHER WORK

Element	Area in sq. m.

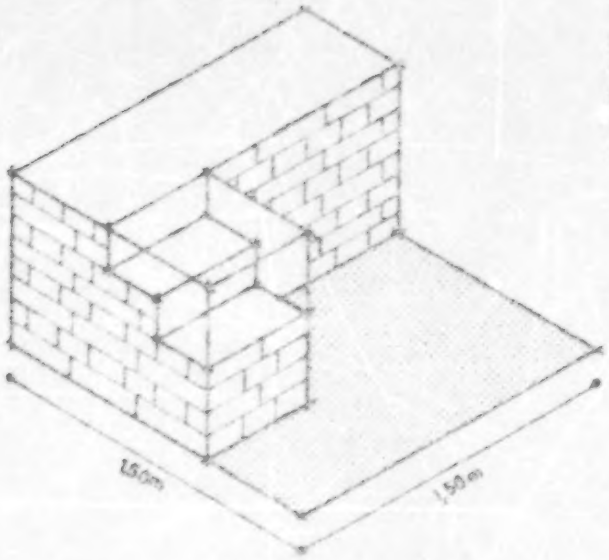
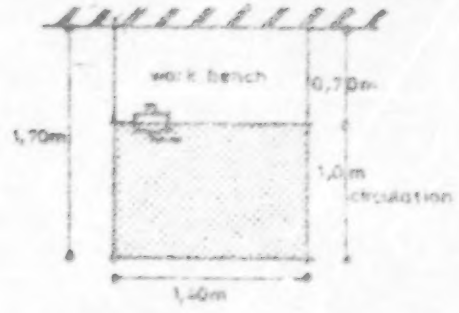
ii) Individual work space



iii) Area for laboratory storage	-	per place	= 0.25
iv) Area for demonstration	-	per place	= 0.25
		TOTAL PER PLACE AREA	= 2.75

ANNEX - 1 Fig.(h)

PER PLACE AREA FOR MASONRY/BUILDING CONSTRUCTION

Element	Area in sq. m.
i) Individual work space	2.25 sq.m. of floor space per place provides for the construction of a model wall and return and for circulation around it.
	2.25
ii) Area for common activities	
	0.30
iii) Area for laboratory tool storage - per place	= 0.25
iv) Area for demonstration - per place	= 0.25
TOTAL PER PLACE AREA	= 3.05

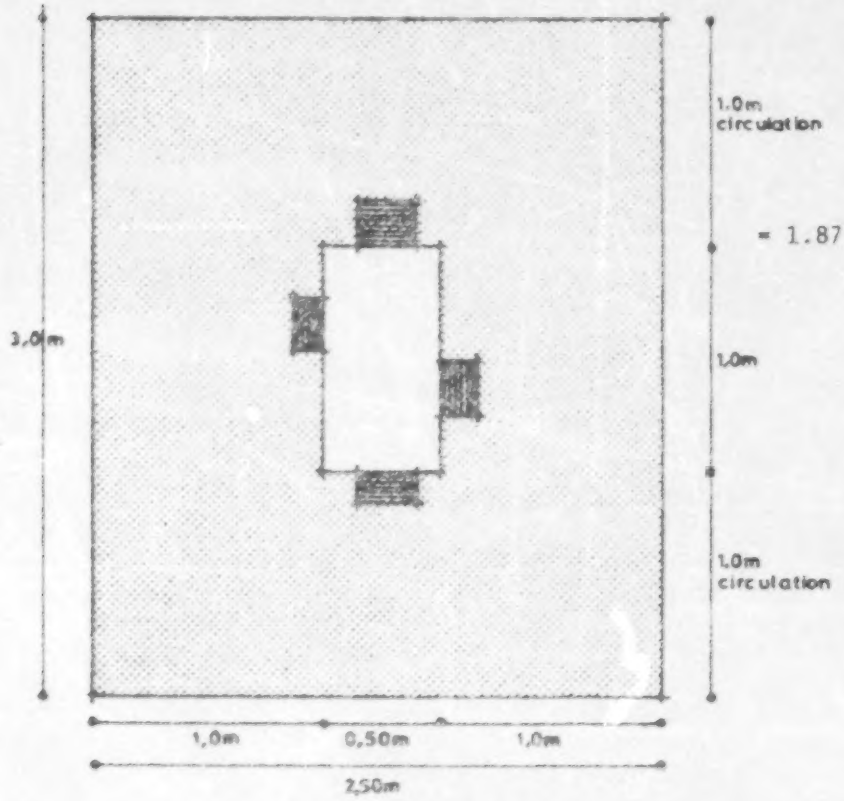
Note: *Much experience in this field can usefully be gained on a suitable concrete apron outside the main building.*

ANNEX - I

Fig.(i)

PER PLACE AREA FOR POWER MECHANICS/MOTOR MECHANICS

Element		Area in sq. m.
ii) Areas for common activities	a) Motors (Petrol/Diesel) (2)	



b) Fitting bench - see Annex I Metal Figure (b)	per place area	=	1.25
c) Vehicle Space should be provided for one vehicle and work space about it. Area say 28 sq.m.	per place area	=	3.50
iii) Area for laboratory tool storage	per place	=	0.25
iv) Area for demonstration - note there may be many demonstration items on the laboratory floor and on boards on walls	per place area	=	1.00
	TOTAL PER PLACE AREA	-	7.87